RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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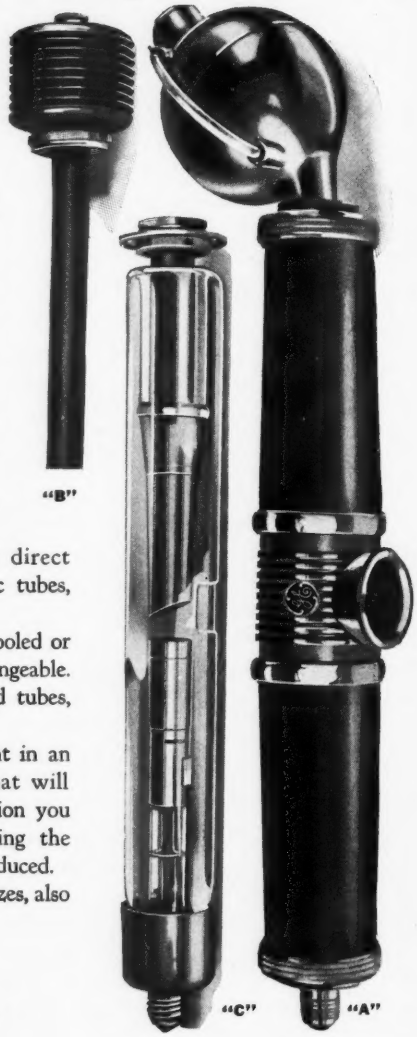

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RADIOLOGY

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THE ORGANIZATION OF A TUMOR CLINIC IN A GENERAL HOSPITAL[1]

By MAX CUTLER, M.D., CHICAGO

Director of Tumor Clinic, Michael Reese Hospital; Consultant in Tumors, Hines Veterans Hospital

THE TECHNIC OF ORGANIZATION

THE problems encountered in the organization of a tumor clinic in a general hospital differ fundamentally from those met with in the organization of special cancer hospitals, although the ultimate goal is similar. Certain principles are fundamental to the successful operation of a tumor clinic.

1. All patients in whom a diagnosis of neoplasm is made or suspected must receive the benefit of consultation before therapy is instituted.

2. The consultation must include opinions upon the clinical, pathologic, and radiotherapeutic aspects of the disease. The number of individuals participating in the consultation necessarily varies under different circumstances.

3. The most efficient surgical procedures, as well as the most modern and up-to-date radiotherapeutic facilities and technic, must be available to the cancer patient.

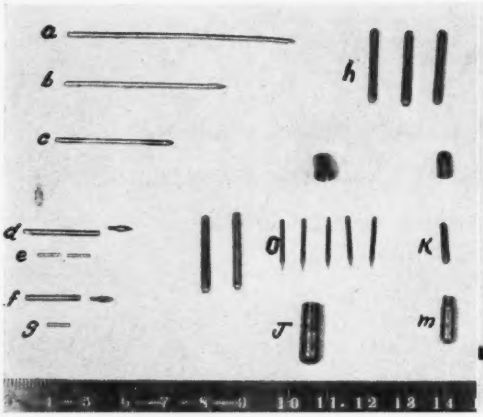
4. There must be a rigid and critical follow-up of all patients treated for benign and malignant tumors; careful records must be made of the end-results.

The technic by which these principles are to be followed can, perhaps, be most easily explained by a statement of the actual operation of the clinic in the Michael Reese Hospital. New patients are referred by the various departments of the hospital to the Out-patient Department of the Tumor Clinic for an opinion. After examination, patients are either referred to the department in which they originated or, at the discretion of the director, may be admitted on the various services of the hospital. All hospitalized ward patients with a diagnosis of neoplasm or suspected neoplasm receive the benefit of consultation by the attending physician on service and the director of the Tumor Clinic. The therapeutic procedures are executed by the surgical attending staff, the Radium Department, or the X-ray Department, as the case may be. After discharge from the hospital, the patient reports to the Tumor Clinic for follow-up examinations.

Personnel.—The personnel necessary for the organization of a tumor clinic in a general hospital varies with the size of the institution, the proposed scope of activities, and the available funds. If a moderate endowment is available, there are obvious advantages in establishing the nucleus of the organization on a full-time basis.

The full-time staff of the Tumor Clinic

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.



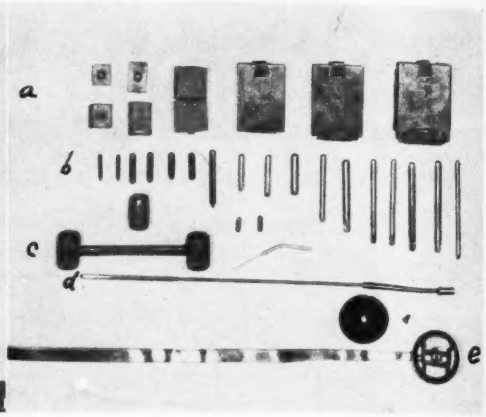


Fig. 1. Various types of radium element needles and tubes in the equipment of the Tumor Clinic. *(a)* Platinum-iridium needle 60 mm. in length, filtration 0.5 mm. Pt, containing 4.8 mgm. of radium element. *(b)* Platinum-iridium needle 44 mm. in length, containing 3 mgm. of radium element. *(c)* Platinum-iridium needle 32 mm. in length, containing 2 mgm. of radium. *(d)* Monel metal needle constructed to hold two removable 1-mgm. cells of 0.2 mm. Pt wall thickness. *(e)* Two removable cells of 0.2 mm. Pt wall thickness, each containing 1 mgm. of radium element. *(f)* Monel metal needle constructed to hold one 1-mgm. removable radium cell. *(g)* A 1-mgm. removable Pt radium cell 6 mm. long, 1 mm. diameter, and 0.2 mm. wall thickness. *(h)* 5-mgm. tubes contained in Pt tubes of 1 mm. wall thickness, having a length of 21.7 mm. and external diameter of 2.65 millimeters. *(j)* Platinum capsule of 1 mm. wall thickness designed to hold 5 monel metal needles, each containing 5 mgm. of radium element. *(o)* Five 5-mgm. monel metal needles 14.5 mm. in length, 1.25 mm. external diameter, 0.25 mm. wall thickness. *(k)* Monel metal tube having a length of 11 mm. and a wall thickness of 0.25 mm. containing 25 mgm. of radium element. *(m)* Platinum capsule designed to hold the 25-mgm. monel tube *(k)*, wall thickness 1 mm. platinum.

Fig. 2. Various surface applicators, capsules, and other radium containers. *(a)* Surface applicators of varying sizes. *(b)* Brass, lead, and aluminum capsules for insertion into cavities. *(c)* The Curie colpostat. *(d)* Holder for 25-mgm. monel tube. *(e)* Vaginal bomb.

in the Michael Reese Hospital consists of: director, assistant, resident interne, radium nurse, two radium technicians, and secretary.

The use of radium, especially when it is employed in the form of the element, introduces certain problems not within the scope of the nursing personnel in a general hospital. The custody of the radium from the point of view of safety, its distribution in various applicators, its sterilization and cleansing, require a special knowledge which the general nurse does not possess. A nurse especially trained to assist in the handling of radium and its application in the treatment of cancer is an indispensable addition to the personnel of a tumor clinic staff. The direct supervision of patients undergoing radium treatment and the nursing of post-radiation reactions are also cared for more safely and efficiently by one specially familiar with these problems. A recognition of these facts has led to the establishment in the Nurses' Training School of the Michael Reese Hospital of a four months' post-graduate course for the purpose of equipping nurses with this special training and rendering them capable of assuming these responsible positions.

X-rays and Radium.—One high voltage X-ray machine is available for deep roentgen therapy. The Tumor Clinic owns 500 mgm. of radium element distributed among 124 containers. In the treatment of carcinomas of the tongue, breast, rectum, and other lesions in which interstitial radiation may be indicated, 70 platinum needles, varying from 1 to 5 cm. in length and 1 to 5 mgm. in radium content, are employed. By means

of Columbia paste moulds, 25 tubes, each containing 5 mgm., are available for application to lesions of the skin and surface mucous membrane according to the Curie technic. These tubes are also employed in the Curie colpostat in the treatment of cancer of the cervix.

Six 25-mgm. tubes are designed for use in the treatment of cancer of the cervix and body of the uterus and for benign uterine and ovarian lesions (myomas, idiopathic uterine bleeding, etc.). The entire 500 mgm., or any available part of it, is utilized in the form of a small radium pack which is applied at a distance of 3 or 4 cm. for external radiation. This pack is useful in the treatment of neoplasms of limited size and depth, for example, recurrent tumors of the parotid, local recurrence of mammary carcinoma, etc.

The quantity of radium necessary in the establishment of a tumor clinic depends upon the number of patients to be treated. The Special Committee of the American College of Surgeons has determined upon 200 mgm. as a minimum requirement. If the Curie technic is employed, utilizing the principle of irradiation with small quantities over long periods, a carcinoma of the cervix can be treated with 60 mgm. of radium, the treatment lasting approximately five and one-half days. Assuming, for example, that 120 mgm. radium are available for the treatment of cancer of the cervix alone, the use of this technic would permit the treatment of 10 cases each month, or approximately 120 cases each year.

Radon.—The question of preference between radium element and radon is of considerable importance in the plans of organization and equipment of tumor clinics. In the special cancer hospitals in which large quantities of radium are available, a part of the radium is placed in solution and a portion is used in the form of the solid element. Assuming that all other factors, *i.e.*, the dose, filtration, and time of irradiation, are the same, there is no proven or demonstrable biologic difference in the effects of radium element and radon. The only difference is that, whereas the intensity of radiation of

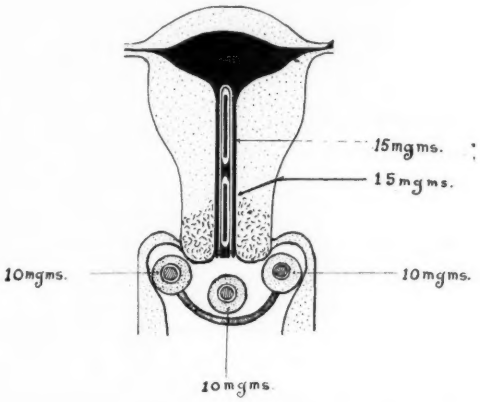


Fig. 3. Distribution of radium in the uterine canal and vagina in the treatment of carcinoma of the cervix. The vaginal applicator is the Curie colpostat. The filtration is 1 mm. Pt and the total dose between 6,000 and 7,500 mgm.-hrs. administered over a period of from 100 to 125 hours.

the element is uniform throughout the period of exposure, the intensity of radon is at a maximum in the beginning of treatment and at a minimum when the exposure is completed.

The preference for one or the other method is a matter of technic. Radon is more adaptable to experimental research in animals, both because of its flexibility and its security against loss.

Favoring the use of radium element over radon, Regaud points to the following advantages:

1. The protection of the health of the personnel. Radium element is usually enclosed in 0.5 to 1 mm. of platinum. With this filtration, there is less danger of injury from soft beta rays.

2. Complete absence of any loss of radio-activity.

3. Absolute equality in the radium content of the containers, permitting greater

perfection in uniform intensity during surface irradiation.

4. The constancy of irradiation.
5. Ability to execute prolonged irradiation without the necessity of recharging the tubes.

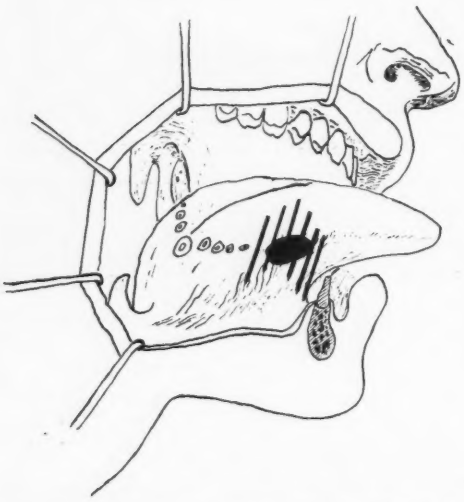


Fig. 4. Arrangement of removable radium element needles in the treatment of carcinoma of the tongue according to the technic of the Curie Institute. The filtration is 0.5 mm. of platinum.

For these reasons, after a long experience, the therapeutic section of the Curie Institute has more and more restricted the use of radon and limited it to animal experimentation.

In the various cancer clinics in England, Belgium, and France, it is interesting to observe that, if both radium element and radon are available, there is a marked tendency to employ the element for clinical therapeutic procedures.

Radium Bombs.—The present state of our knowledge does not permit an absolute decision upon the efficacy of large quantities of radium employed in the form of a bomb in the treatment of deep-seated neoplasms. Highly radioresistant tumors that have failed to respond to high voltage roentgentherapy have not yielded to treatment with the radium bomb. On the other hand, experience with this method in some of the European centers has been more encouraging, particularly in the treatment of epidermoid carcinoma of the tonsil, pharynx and larynx, and parametrial extension from carcinoma of the cervix. It is also of interest to consider that the unique results of Coutard in roentgentherapy of carcinoma of the larynx, pharynx, and tonsil were accomplished by a technic designed to imitate the gamma ray of radium, both as to penetration and prolonged time of exposure.

The writer is of the opinion that these results can be duplicated and possibly improved by the use of a 4-gm. radium bomb with less constitutional effect upon the patient. In an effort to conduct further observations along these lines a 4-gm. radium element bomb, similar to that now in use in the Memorial Hospital, New York, has been installed in the Tumor Clinic of the Michael Reese Hospital.

IMPROVEMENTS IN SERVICE

Clinical Diagnosis.—The clinical diagnosis of cancer is becoming increasingly more difficult as the disease is encountered in its earlier stages. Accuracy in diagnosis is based upon extensive clinical and pathologic experience. By increasing and concentrating clinical material and by focusing interest and attention upon the recognition of early and borderline lesions, the organization of a tumor clinic results in accumulation of valuable experience by members of its staff and, consequently, an increase in the accuracy of clinical diagnosis and interpretation of early cancer.

Biopsy: Indications and Contra-indications.—The proper selection of the site and extent of the excision and the correct technic of biopsy, in order to avoid trauma and dissemination, are matters of the greatest importance in the diagnosis and treatment of cancer and upon the subsequent course of the disease, yet this important service is not

efficiently performed in most general hospitals. The development of this aspect of the service and the perfection of technic constitute an important function of the tumor clinic staff.

Microscopic Diagnosis.—Recent clinical and pathologic investigations have established certain important relations between the microscopic appearances of tumors and their response to radiation therapy. Equally significant observations have confirmed the existence of certain tumors which possess characteristic morphologic appearances that are accompanied by an extremely unfavorable and usually hopeless prognosis in response to surgical therapy, but which are highly radiosensitive. The information that may be elicited from microscopic examination of biopsy specimens may, therefore, under certain circumstances, constitute an important guide in the choice of therapeutic procedures. Thus, anaplastic carcinoma of the fundus uteri is cured in a small percentage of cases by combined radiation and hysterectomy, but it is invariably fatal when hysterectomy alone is performed. Lymphoepithelioma and transitional-cell carcinoma of the tonsil yield about 30 per cent cures by radiation therapy, but none by surgical methods. Thus it is evident that an adequate pathologic report must contain information upon the anaplasia and radiosensitivity of the tumor.

Surgical Therapy.—General hospitals are usually adequately equipped with surgical facilities for executing all procedures in the surgical treatment of cancer. The results of surgery in the major forms of the disease vary with the training, skill, and experience of the surgical personnel. It is universally recognized and agreed that the surgery of cancer is a specialty and that the operative mortality, as well as the results, vary within wide limits. The concentration of surgical cancer cases of limited regions of the body in the hands of individual surgeons tends to develop competent specialists in limited fields. This end can be best accomplished by a system of special assignments such as is practised in the Massachusetts General Hospital and in the Michael Reese Hospital. A definite improvement in results and lowering of operative mortality have been demonstrated in institutions in which this principle has been adopted.

Radiation Therapy.—It is not within the scope of this communication to discuss the details of the technic employed in the radiation treatment of cancer, but it may be of interest to state broadly the principles which dominate our radiotherapeutic procedures.

(A) External Radiation.—All cases in which radiotherapy has been selected as the method of treatment are divided into two categories: palliative and curative. The scheme of therapy is decidedly different in the two circumstances. When it is proposed to effect palliation, moderate exposures in divided doses are administered at intervals in an effort to induce growth restraint, reduce pain, and to prevent or control extension of the disease, ulceration, infection, and hemorrhage.

When the character of the lesion justifies an attempt to cure, the scheme of therapy is altogether different. We agree with Regaud that the most effective method is that which administers to the lesion a uniform, homogeneous, penetrating irradiation of an intensity sufficient to effect complete destruction of the tumor, and closely approaching, but not reaching, the tolerance of the surrounding normal tissues. The advantage of this scheme of therapy over prolonged and repeated irradiations appears to us to have been fully demonstrated.

The precise optimum period of irradiation has never been fully established. In the treatment of epidermoid carcinoma of the tonsil, hypopharynx, and larynx, Regaud and Coutard are of the opinion that the optimum period of irradiation with X-rays is between 14 and 21 days. It is highly probable that the excellent results obtained in

this group of cases in the Curie Institute are due principally to the prolonged time factor. It should be noted, however, that the prolonged period of irradiation permits of the administration of a much greater dose than could be delivered during a shorter period. It is possible, indeed probable, that both these factors play a part in the favorable results that have been effected in this group of tumors.

The success attained by Coutard in the treatment of carcinomas of the tonsil, pharynx, and larynx by his special technic of roentgentherapy constitutes a most important advance in the radiotherapy of cancer, especially when it is considered that, in many of the cured cases, the lesions were fully developed, adult, squamous carcinomas of the most radioresistant type. The importance of manipulating the intensity, rate, and time of irradiation in an effort to induce a characteristic reaction in the tumor bed is fully justified by the results. In order to induce this reaction, the so-called "radio-epithelite" of Regaud, it is often necessary to administer a dose of sufficient intensity to cause a complete destruction of the superficial layers of the epidermis, or a so-called "radio-epidermite." When circumstances permit the use of multiple portals of entry, the intra-oral reaction can be elicited without the intense skin reactions that have been described.

(B) Interstitial Radiation.—In the treatment of carcinoma of the tongue, the writer is impressed with the advantages of the use of removable platinum needles over radon seeds. The superiority of the results by the former method is due mainly to two factors: the use of adequate filtration (0.5 mm. Pt) and uniformity of distribution of the radiation. The difficulty of distributing radon seeds uniformly throughout a tumor mass is perfectly obvious from studies of tissues removed after radium implantation. Even in the most experienced hands an uneven grouping of seeds is frequently unavoidable, resulting in areas of necrosis in foci which are over-irradiated by a group of radium seeds of inadequate filtration. The technical difficulty is distinctly less marked when removable platinum needles are employed. The same considerations apply to the treatment of carcinoma of the breast in which, on account of the great extent of the area involved, a uniform distribution is even more important and more difficult. In this connection I should like to state my position on the radiation treatment of mammary carcinoma. The available evidence does not justify the use of radiation alone in a strictly operable mammary carcinoma. The difficulties of deciding upon the presumable operability of mammary carcinoma by clinical examination are insurmountable.

SUMMARY AND CONCLUSIONS

1. Because of the exceptional difficulties involved in the treatment of cancer, a grave responsibility rests upon the trustees and staff of any institution that undertakes the organization of a tumor clinic, particularly in the choice of a competent directing personnel, adequate equipment, and perfection of organization.

2. Centralization of clinical and pathologic tumor material permits the assembling of information which exceeds the experience of any one individual, thereby raising the level of efficiency in the diagnosis and treatment of cancer in hospitals and in communities in which a well organized tumor clinic exists.

3. Free consultation and interchange of opinion on all cases before any form of treatment is begun give the patient the benefit of the combined experience of a group of specialists. They are particularly important since the initial procedure frequently determines the ultimate result. In no field of medicine is the intimate co-operation of a group so indispensable as in the treatment of cancer.

4. The allotment of groups of cases to

individual members of the staff through a system of special assignments promotes interest, concentrates clinical and pathologic experience, and facilitates study, research, and education.

5. An expression of expert opinion upon the choice between surgery and radiation in the treatment of benign and malignant tumors is of prime importance and constitutes the most valuable single service that the tumor clinic can render to the staff of the general hospital.

6. It cannot be too strongly emphasized that the success and efficiency of a tumor clinic can be only as great as the training and experience of the directing personnel. The outstanding obstacle to the rapid development and organization of tumor clinics throughout this country is the lack of adequately trained men capable of directing such units. It is most important, therefore, that special cancer and tumor clinics in the larger general hospitals include in the activities of their organizations a program of prolonged post-graduate training in the form of fellowships similar to those in the Memorial Hospital, New York City. Thus will younger men be equipped with thorough training and experience such as will render them capable of assuming directorship of the proposed cancer units or tumor clinics in general hospitals. This is an educational activity of prime importance in the problem of cancer control and one entirely worthy of financial support.

DISCUSSION

DR. F. C. WOOD (New York, N. Y.): Dr. Max Cutler has had the great opportunity of coming to a hospital with an endowment, the medical staff and managers of which desired that a cancer clinic should be developed. He has had the opportunity of seeing European technic and he has had long training at Memorial Hospital. He came ideally equipped with surgical and radiologic training to a new situation, which was also ideal.

I heard Dr. James Ewing say last year, at the College of Surgeons' meeting, that there should be established research institutes for cancer and that $10,000,000 was a proper endowment. Ten million dollars for an endowment for an institute is a delightful sum but we can only dream of it as an ideal. It may come, but what are we going to do to-day?

Michael Reese Hospital is one of the finest in the country, but what are we going to do with a hospital in a relatively small town of fifty or a hundred thousand people, without much support? How are you going to help the cancer patient? That is the real question in this country. What is the radiologist going to do in a small hospital, without much money?

The first thing to do is to recognize the situation—that the surgical union is at present against the development of cancer clinics. The surgeons have been in a union since the time of Hippocrates. It does splendid work, cures many operable cancers, but it does not especially care about radiologists.

Send the surgeon all the operable cases. If you hand him all the operable cases, he will let you have the inoperables. How many of the cancer patients that come to your hospital is the radiologist going to get? About 90 per cent. The surgeon may think that 10 per cent more are operable. Give them to him. That leaves you 80 per cent.

I find that when I take a case to a surgeon and say, "This case is operable," the surgeon says, "Oh, no. No, you take him." But, if he thinks you are stealing cases from him, he comes down and says, "Here, let's abolish this department."

If you start that way, in the course of a couple of years your surgeons will be friendly, they will begin shifting cases down to you and saying, "You did pretty well with that one, better than I could have done. That's fine. He couldn't have had cancer."

That is the first answer. You have to prove from the pathologist's records that the patient did have cancer, but finally, in the course of a couple of years, you will have the confidence

of the surgeons that you are not going to steal their patients from them.

You also have to convince the doctor or ordinary fellow who sends you cases that it is to his advantage to lose that case to you for treatment; you can do better than he can—the ointment fellow, the fellow who straps the breast, and the fellow who treats carcinoma with ultra-violet light. Show him he is going to lose more money in the long run by treating these cases improperly than if he refers them to this little beginning clinic.

In that little beginning clinic, the first thing is not brains, but a real human heart. Remember, everyone of those patients thinks he is going to die pretty soon. You have to conceal that from him. You have to have a cheerful place. Segregate the horribles from the others. Have them at a time when the other people can not see these terrible cases, or even smell them. You have to treat these patients with the utmost patience and care.

There is a lot of medical treatment you can do for a hopeless cancer patient—a little X-ray, some codeine, careful dressings, see about his food, see if you can help him in some way—let him know you are interested. Such patients have to be treated with the greatest kindness. They are the most pitiable people in the world because nobody wants to see them.

If you can begin to treat cancer medically and radiologically, pretty soon the surgeon will come downstairs and say, "Tell me what you are doing down here." Get the nose and throat men to come down and see a couple of larynx cases. Then if you do what Dr. Coutard has shown and Dr. Cutler talked about, if you have a good X-ray machine and you can get the fellow to stand it, you will get one-third of the cases of carcinoma of the larynx.

At Memorial Hospital, Dr. Cutler used to insert seeds. Now he goes to Europe and decides not to insert seeds. You cannot all visit Europe, but you can read Dr. Cutler's paper in RADIOLOGY and learn Regaud's method of not inserting seeds indiscriminately, but putting in needles of a particular sort.

The little clinic is not going to have $100,000 worth of radium. It is going to have, perhaps, one X-ray machine. It may be run at only 150,000 volts. If that is so, do not sit and cry because you cannot go to 200,000 volts. You can help a lot of people with 150,000 or even 130,000 volts. The ordinary X-ray machine will bring a lot of comfort to patients with bone metastasis. You can not cure them as Dr. Pfahler can. They do not expect to live forever. If we can give them a year's life, two years' life, they may live longer than some of us will.

Meanwhile, you will not have any trouble with the little cancer clinic. Do not start too big. Begin slowly. Help a few patients. Pretty soon you will get everything in the hospital coming your way because you are doing good work, for the patients will talk about it. If you bring in the outside doctor and very quietly show him what he should have done and did not do, he will soon be sending you patients.

In a town of 100,000 you cannot expect to have an expert dermatologist, an expert ophthalmologist, an expert nose and throat man. But if you can get some younger men willing to be trained, willing to come in and see these cases, they can see more interesting material in your cancer clinic than they can see anywhere else, and gradually they will grow.

Finally, your clinic will feed back into your hospital a lot of interesting cases. If you get cases which you cannot handle, be perfectly frank about it and send them where they can be handled. That is the great factor—honesty. Face your limitations. We will never, for example, be able to cure more than a small percentage of carcinomas of the stomach, and the surgeons will be the only ones to do it. Do not try to cure cancer of the stomach with radiation.

If within fifty or a hundred miles there is a tenderhearted surgeon who will not charge poor people very much, railroad them to him. The cancer patient can always travel to get the best. The best cancer treatment in the world is carried on to-day in Sweden where the Government pays the patient's expenses to the Radiumhemmet, in Stockholm. After having received it, patients become obligated to

the Government; when the doctor wants to hear from them, he sends them a note saying that they are Government employees, and they have to come down and be seen. The Government gives the physician power to follow them up. All that is necessary is to send them a note. But Sweden is a little country and much is possible there that we can not do.

Do not play favorites in surgery. If you chance to be in central Ohio, and there is a fine surgeon in Cleveland who can do beautiful work in one line, why should not a patient in Columbus be told that he can get the best results in Cleveland? Your little clinic can send the patients where they can get the best results. Pretty soon one of your own young surgeons will ask the man in Cleveland to show him, and then your own will do the operating you want him to do and your cancer clinic will be more effective than before.

To my mind that is the whole backbone and explanation of a cancer clinic—you must furnish good diagnoses, careful and kindly treatment of your patients, and establish good relations with your surgeons and medical men. They will want to get rid of some of their cancer patients, so they will say, "Take them." At present, most cancer cases belong to the radiologist, but do not try to cure what some other man can treat more efficiently.

Million-volt X-ray Tube Begins Experimental Operation.—The new million-volt X-ray tube of the California Institute of Technology is being operated regularly and at a potential up to 1,200,000 volts. The research staff in charge of the large tube, headed by Dr. Charles C. Lauritsen, has made careful measurements of the intensity of the radiation produced and the limit of the length of short wave radiation has been determined by means of a specially designed crystal spectrograph.

In quantity of radiation produced the million-volt tube equals many times the amount of radium available for medical use in the world at present, the intensity being twenty roentgens at a distance of seventy centimeters from the target. This is equivalent, according to measurements made at the New York Memorial Hospital, to the raying power of at least two kilograms of radium, which would cost at present prices about $120,000,000.

The shortest wave length radiation produced is twelve X-units, which is less than most of that produced by radium.

Some research is now being done on the effects of the X-rays from this tube upon animals. The tube is to be used especially for biological work.

The million-volt tube is essentially a large and much modified edition of the conventional X-ray tube used in medical radiology but is operated with alternating current. In this it differs from tubes of lower voltages at the Memorial Hospital in New York City and at Schenectady. To supply the tube with current at a million volts potential, large transformers were built to order. These deliver sufficient current to light three hundred 100-watt lamps. —*Science Service.*

PECULIAR REGENERATION OF BONE, FOLLOWING MAGGOT TREATMENT OF OSTEOMYELITIS

By MAURICE M. POMERANZ, M.D., Hospital for Joint Diseases, New York City

THE recent investigations of Buchman and Blair (1) on the effect of maggot therapy in osteomyelitis afforded me an opportunity to study the roentgenograms of cases so treated.

The regeneration of bone in the diseased part is different from that which occurs in other methods of treatment and a description of it will be of interest to roentgenologists. In order to appreciate the significant variations, we must review the changes in bone as the result of an infectious process and the reaction of this bone to the hitherto accepted methods of treatment. We can then more fully appreciate the peculiar nature of the reaction following maggot therapy.

Infectious inflammatory lesions in bone may occur in the medulla, cortex, or periosteum, usually, however, in the medulla. The most important change is destruction involving the medulla, perhaps even the cortex. This is usually noted as a local area of osteoporosis or cancellous destruction involving the bone, usually at the site of the nutrient vessel supplying the segment. The size of the destroyed area will, of course, vary with the size of the vascular channel involved. If the main nutrient vessel is involved, the entire shaft may be destroyed. If a small terminal vessel is occluded, a localized area of necrosis (abscess) may be noted. The infection may then spread by means of the haversian canals to contiguous sections of bone, at times leaving islands of normal, uninvolved tissue. It is possible at this stage for multiple areas of destruction to be present. The pus may burrow through the canals, devitalizing the tissue and completely separating small segments of bone. If the infection occurs beneath the periosteum, it may burrow up and down this sheath and elevate it, producing extensive periostitis. The cortex may, or may not, be involved. If it is, we have an osteoperiostitis. Occasionally, the infection becomes fairly well walled off and a localized subperiosteal abscess results. The new bone is deposited so that it may materially increase the diameter of the shaft, and it is important to remember that this increase is due to new bone deposit, and not to expansion. There is, however, retention of the general contour of the shaft. In chronic cases, reactive manifestations occur. These take the form of osteosclerosis, cortical thickening, or periosteal proliferation, usually combined to a variable degree. In the small bone abscess, a dense sclerotic wall may be produced; or, as sometimes happens, the earliest indication of a cortical abscess may be the slight periosteal reaction. The periostitis is usually rough and irregular, the bone being deposited in layers parallel to the long axis of the shaft. If the destroyed area involves the ends of long bones, direct extension into the joint and into all the bones of the joint may occur.

The process of bone regeneration is fundamental, but there is some difference in the manner in which the new bone is produced, depending on the type of treatment.

The procedure employed in localized bone abscesses is dependent on the site of the lesion. In the subperiosteal type, an incision over the bulging periosteum will evacuate thoroughly the infected area. The roentgenogram will show a slight erosion of the cortex with periosteal thickening. The defect in the cortex may quickly disappear or persist as a small punched-out area, the margins of which become well rounded with the passage of time. Periosteal thickening re-

Fig. 1. March 28, 1931. Saucerized area in the tibia prepared for implantation of maggots. The sequestrum was extruded spontaneously during treatment.

Fig. 2. May 22, 1931. There is osteoplastic callus formation over the excavated area on the inner surface of the tibia, projecting into the soft tissues. The large medullary defect represents through-and-through perforation of the bone.

Fig. 3. Dec. 14, 1931. Contraction and condensation of the new-formed bone. Note the homogeneous eburnation of the medulla. The perforation in the bone is closing. There is early reconstruction, and new cortex has formed on the anterior surface of the shaft.

sults and often, curiously enough, may extend beyond the involved area despite the absence of active infection.

A common method of treatment of medullary bone abscesses is evacuation by the use of the bone drill to establish a drainage channel. Roentgenographically this channel is easily detected. Healing is slightly different from that which occurs in the subperiosteal abscess. The medullary infection may be walled off by a dense eburnated border. If it is not walled off, regeneration of cancellous bone may begin in the abscess cavity first and then extend throughout the excavated channel. This is the most favorable result, since healing occurs simultaneously in the abscess cavity and in the drainage tract. Should the abscess cavity be large, or walled off, regeneration of bone in the drainage channel may occur before it does in the abscess. In this event a localized sterile vacuole in the bone may persist for years or else recur as an abscess. The question of the activity of the lesion may be extremely difficult to decide from the roentgenogram and, in most instances, it will depend solely on the local symptoms. In any event, the end-result of the drill operation is the creation of a sclerotic channel which may extend into a cavity representing the original abscess. The defect in the medulla persists for a considerable time. It is interesting to note that very little, if any, periosteal reaction occurs, despite the disturbance in its integrity. I have followed some of these cases for many years, and in practically all the sclerotic path of the drill can still be detected.

It is often possible to identify the method of treatment employed in massive osteomyelitic processes by close inspection of the X-ray plates.

The Orr method is employed to permit free drainage of the infected area. As the saucerization of the part is extensive, fractures are imminent and immobilization is accomplished by use of a plaster bandage. A roentgenogram of the area so treated is characteristic. Bone regeneration is slow

and usually begins in the excavated area, gradually filling the defect produced surgically. This new bone is extremely dense and somewhat irregular in character. Reconstruction of a new cortex is not so characteristic as that which ensues after maggot therapy and periosteal thickening is often extensive.

The purpose of the Carrel-Dakin method is to disinfect the diseased area by means of a chemical solution after drainage has been established. The regeneration of bone following irrigation is extremely slow and somewhat irregular. Alternating patches of osteosclerosis and osteoporosis are common, and recurrences of the infection are not infrequent. The cortical and medullary thickening may be extremely marked. Occasionally, one sees linear calcification in the soft parts, probably due to irritation from the chemical, in the nature of a myositis ossificans or else to the actual deposit of the chemical in the soft part. This linear calcification is extremely uncommon in osteomyelitis except in cases treated by this method.

The roentgenograms of an infected area treated by the maggot method are fairly typical. The process of healing may be divided into three stages which are radiographically recognizable.

The first, or exudative stage, is noted in from one week to 10 days, occasionally as early as six days, following saucerization. At this time, an osteoplastic process is noted which begins in the medulla, extending into the soft tissues immediately overlying the part. It does not extend beyond the excavated zone. While this material approximates the density, nevertheless it lacks the homogeneity of callus. Its borders are well defined, and within the mass proper vacuolated areas suggest the formation of cancellous bone. This appearance persists for from two to four weeks, when the second, or contractile stage, is initiated. This stage is recognized by the contraction of the mass from the soft tissues down to the underlying bone, so that the approximate caliber of the shaft is re-established. As it contracts it appears to become denser so that it is as dense as the bone of which it is a component part. The new-formed tissue appears to fill in the gap produced by the saucerization. At this stage, there is no differentiation between medulla and cortex. The terminal, or reconstructive, stage is noted about six months after the operation. The excavated area is well rounded and the medulla is replaced by dense eburnated bone. I believe it perfectly conceivable that this eburnated bone will become replaced in its proper location by a new medullary cavity similar to that which occurs in old fractures of the shafts of long bones. Further condensation at the periphery of the shaft probably indicates the reconstruction of a new cortex.

Despite the limited period of observation of these cases, it can be stated that, following the maggot treatment, there is unusual regeneration of bone, resembling in its nature callus formation. It is also permissible to conclude that healing is more rapid and that the end product approximates more closely normal bone structure than any of the hitherto accepted methods of treatment.

REFERENCE

(1) Buchman and Blair: Maggots and Their Use in the Treatment of Chronic Osteomyelitis. Surg., Gynec. and Obst., in press.

VISCERAL DISPLACEMENT IN PNEUMONIA[1]

A ROENTGENOLOGIC AND EXPERIMENTAL STUDY

By CHING WU, M.D., CHICAGO
From the Division of Roentgenology, Department of Medicine, University of Chicago

INTRODUCTION

MEDIASTINAL displacement and diaphragmatic elevation are commonplace findings in massive atelectasis and in certain phases of pulmonary tuberculosis, and physicians are beginning to realize that they may occur also in lobar pneumonia.

Van Allen and I (1) have reported several instances in experimental dogs. Thoenes (2) reported 11 cases of pneumonia, all showing displacement of the heart to the affected side. Wallgren (3) stated that he had frequently observed, in the pneumonias of young children, displacement of the heart to the affected side. St. Engel (4) considered elevation of the diaphragm on the affected side a common occurrence in lobar pneumonia. Griffith (5) reported displacement of the heart to the affected side in 16 out of 40 cases of lobar pneumonia in very young children. Coryllos and Birnbaum (6) reported mediastinal and diaphragmatic displacement toward the affected side in experimental pneumonia in dogs and stated that they frequently found the heart and trachea similarly displaced in human subjects. Hart (7) considered displacement of heart, trachea, and diaphragm toward the affected lung common in pneumonia.

The present communication deals with the roentgenographic findings relative to the diaphragm and mediastinum in 40 cases of lobar pneumonia admitted to the University of Chicago Clinics during the years 1928 to 1931 and in something over a hundred cases of experimental pneumonias in dogs,

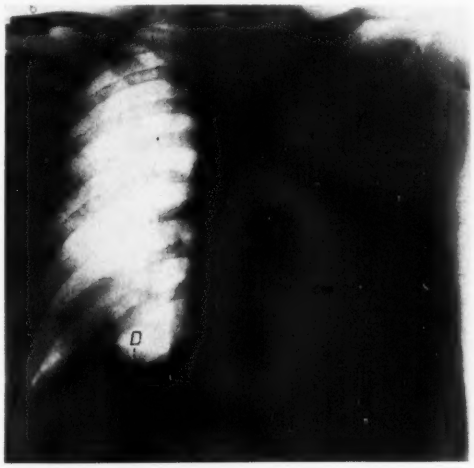


Fig. 1. Fifth day of lobar pneumonia involving almost entire left lung and part of right lower lobe. Accidental respiratory movements during filming show normal excursion of right diaphragm, left diaphragm completely obscured. Note heart displaced to the left until it is scarely seen at all at the right of the spine.

published recently by Terrell and Robertson (8).

METHODS

The ideal roentgenographic examination in a study of this sort would consist of stereoscopic roentgenograms of the chest with the subject standing or sitting facing the films, plus fluoroscopic observation with the subject in the erect position. Obviously, however, most pneumonia patients cannot be submitted to such maneuvers.

Although Hodges and Robertson have conducted preliminary unpublished experiments which hold promise of allowing repeated routine fluoroscopy and stereoscopic roentgenograms of even the sickest pneumonia patients, these facilities are not available at present. Furthermore, most of the

[1]In this study I have had the advice and assistance of Dr. Robertson, Dr. Hodges, and Dr. Coggeshall, of the University of Chicago.

Fig. 2-*A*.—Third day of lobar pneumonia involving middle third of left lung. Note elevation of left diaphragm and displacement of heart to the affected side.

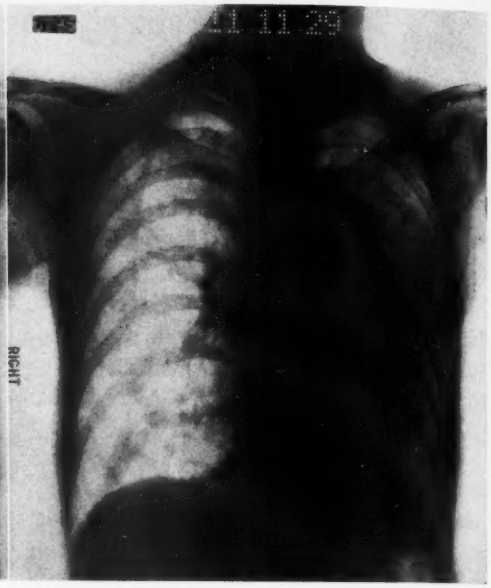


Fig. 2-*B*. Same case as shown in Figure 2-*A*. Fourth day of lobar pneumonia involving almost entire left lower lobe and part of left upper lobe. Note displacement of the mediastinum, including heart, to the left side.

films available had been made by others before I began my study so I had to be content with series of non-stereoscopic chest films made with the subject in the dorsal position in bed, positioned more or less carefully depending upon his condition and upon the skill and diligence of the roentgenology house-officer who happened to be on duty at the time the film was made. I have supervised the making of most of these films during the past six months (nine of the total number of cases) and I have taken care to position the patient with the sagittal plane of the chest parallel with the radiation—that is, with the patient in the true anteroposterior position, not rotated to one side or the other. Furthermore, I have made free use of the double-exposure technic reported by Jung and Van Allen (9) and subsequently reported independently by Thomas. Briefly, this consists of placing the film beneath the patient as if for an ordinary single chest film, asking him to inhale, exhale, and then hold his breath in complete expiration. An X-ray exposure is made, the duration being three-fourths of the estimated full exposure. Without moving the patient or the film, the patient is told to take and hold a full breath, and an additional exposure, one-eighth of the estimated normal exposure time, is made.

ABSTRACTS OF CASES

Case 1. P. H., age 43 years, was admitted to the hospital on Jan. 7, 1930, following fever and chills of 24 hours' duration. On physical examination dullness over the left middle area posteriorly, diminished breath sounds and fine râles were noted. The roentgenogram showed a patch of density in the base of the right lung and complete consolidation of the lower lobe of the left lung.

January 8, 9, and 10.—Roentgenograms

showed steady increase of the left lower lobe consolidation with a slight increase of the lesion at the base of the right lung. There was slight displacement of the mediastinum and the heart to the left. The left diaphragm was obscured by clouding of the left base.

January 11.—The right lung (Fig. 1) was clear except for a patch of consolidation at the base. The left lung showed complete consolidation from the apex to the base. There was seemingly frank displacement of the heart to the left.

Death occurred on January 14. Autopsy showed consolidation of the right and left lower lobes, with the lower two-thirds of the upper lobe in a stage of gray hepatization.

Case 2. E. Z., age 77 years, was admitted to the hospital on Nov. 6, 1929, following fever, anorexia, and a slight cough of two days' duration. Physical examination disclosed dullness with diminished breath sounds in the left lower lobe and râles in the left apex.

November 7.—The roentgenogram (Fig. 2-*A*) showed clouding in the middle third of the left lung. The left diaphragm was elevated and there was slight shifting of the heart to the left side.

November 11.—Diffuse clouding of the entire left lower lobe and slight graying of the upper lobe were seen (Fig. 2-*B*). There was displacement of the mediastinum and the heart to the left.

Death occurred on November 15. Autopsy showed a consolidated mass of the left lower lobe in a stage of gray hepatization.

Case 3. A. C., age 61 years, was admitted to the hospital on Jan. 5, 1930, following fever and pain in the right chest. On physical examination diminished breath sounds and bronchial breathing, right lower lobe, were noted. The roentgenogram showed

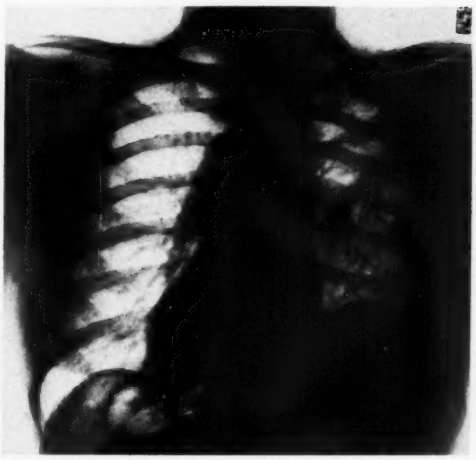


Fig. 3. Fifteenth day of resolving lobar pneumonia of right lung. Note marked elevation of right diaphragm and slight mediastinal displacement to the affected side.

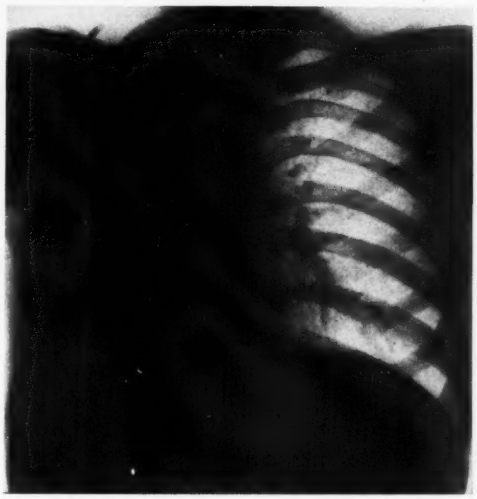


Fig. 4. Seventh day of lobar pneumonia of left lung. Note displacement of the mediastinum, including heart, to the affected side. Left diaphragm slightly elevated.

definite clouding of the right middle and lower areas.

January 16.—There was frank clearing of the clouding in the right lung. The right diaphragm was markedly elevated, and there was slight displacement of the mediastinum and the heart to right (Fig. 3).

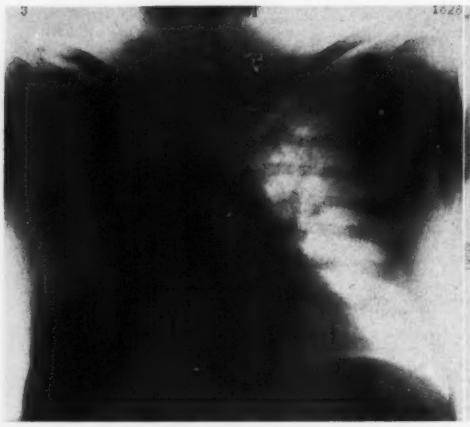


Fig. 5-*A*. Eighth day of lobar pneumonia of right lung. Note marked elevation of the diaphragm on the affected side.

Fig. 5-*B*. Same case as shown in Figure 5-*A*. Double exposure roentgenogram; shows free movement of the diaphragm on the normal side *(D'-D')* and very slight movement of the diaphragm on the affected side in the original X-ray film.

January 21.—There was practically complete resolution of the pneumonia of the right lung, but the right diaphragm was still higher than normal. The mediastinum had almost returned to its normal position.

Case 4. H. C., age 21 years, was admitted to the hospital on Jan. 1, 1931, following fever and cough of five days' duration. Physical examination revealed marked dullness and decreased breath sounds in the left chest.

January 2.—A roentgenogram (Fig. 4) showed diffuse clouding of the entire left lung. There was displacement of the mediastinum and the heart to the left. The left diaphragm was slightly elevated.

January 10.—The lungs were essentially clear. The diaphragm and mediastinum were normal in position.

Case 5. J. K., age 35 years, was admitted to the hospital on Nov. 14, 1931, with a complaint of having been ill for six days. On physical examination, diminished breath sounds were noted in the right lower lobe posteriorly.

November 16.—A roentgenogram (Fig. 5-*A*) showed marked elevation of the right diaphragm and diffuse clouding of the right lung.

November 17.—A double exposure roentgenogram (Fig. 5-*B*) showed elevation and decreased excursion of the right diaphragm. The patient died on November 17; no autopsy was held.

Case 6. A. W., age 39 years, was examined on Oct. 24, 1931. The patient had had a temperature and complained of soreness in the left lower chest five days after operation for Hunner's ulcer of the urinary bladder. On physical examination, suppression of breath sounds and crepitant râles in the left lower chest were noted.

October 29.—A double exposure roentgenogram (Fig. 6) showed elevation and diminished excursion of the left diaphragm, with clouding in the left lower lung.

November 9.—There was practically complete clearing of the clouding in the left lung base. The left diaphragm had returned to normal position.

Case 8. R. B., age 40 years, was admitted to the hospital on April 8, 1930, following fever, cough, and soreness of the chest of five days' duration. On physical examina-

tion changes in the right lower chest were apparent. A roentgenogram showed slight graying in the right middle lung field and that the right diaphragm was elevated.

April 9 and 10.—Roentgenograms showed marked clouding of the right lung and an elevated right diaphragm.

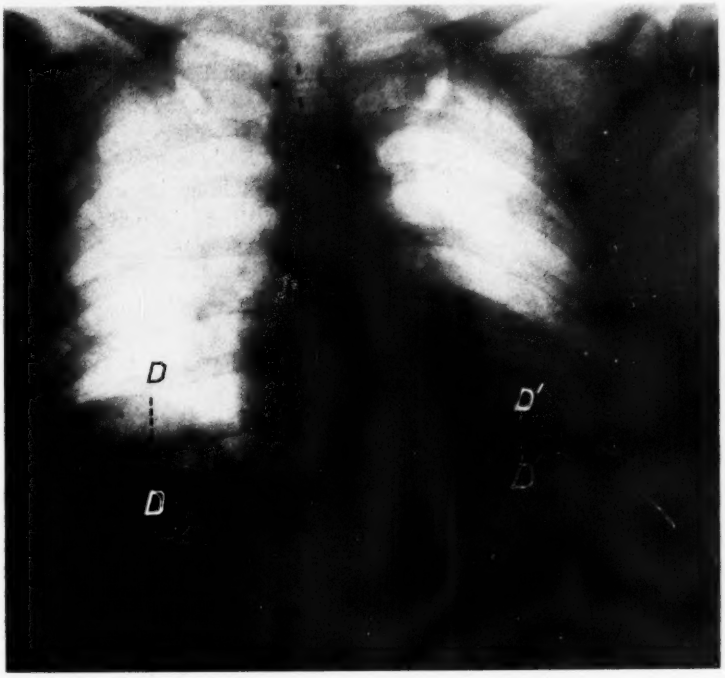


Fig. 6. Double-exposure roentgenogram of post-operative pneumonia of left lower lobe. Note elevation and decreased excursion of the diaphragm on the affected side. Right diaphragmatic excursion measures 4 cm. (*D-D*). Left diaphragmatic excursion measures 1½ cm. (*D'-D'*).

April 12.—There was some clearing of the clouding in the right middle and lower areas (Fig. 7). The patient breathed during filming and respiratory movements of the diaphragm were well visualized on both sides. The right diaphragm was elevated and moved with diminished excursion.

ANIMAL EXPERIMENTS

Terrell, Robertson, and Coggeshall have made available to me the X-ray films made in their large series of experimental pneumonias, and I have been able to do the roentgenographic work for them in approximately 20 of the more recent experiments. Their earlier films were made with the animal strapped to a board that has been described by them, but I have employed a modification of their apparatus which I believe facilitates the orienting of the animal in the true recumbent position (Fig. 8). The dog is placed on his back with his prominent spinal ridge lying in the trough of the aluminum window *(A)* and the telescopic side rails *(G)* are lengthened or shortened until the head fits the head restrainer *(D)*. The forelegs are tied down to the line cleats *(B)* which have been so placed that the scapulæ are drawn as far as possible away from the lung field. The hindlegs are lashed to the wooden posts *(F)*. If the animal is restless,

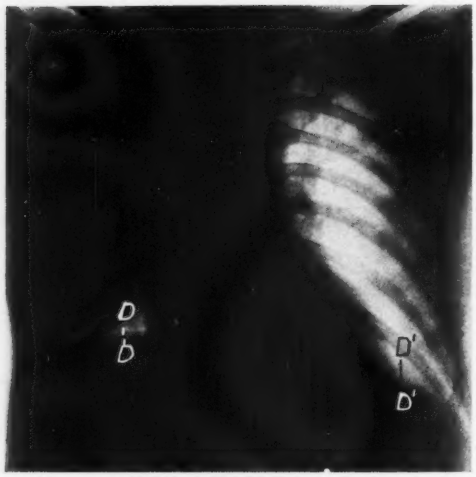


Fig. 7. Fifth day of lobar pnuemonia of right lung. Accidental respiratory movements during filming show diminished excursion and elevation of diaphragm on the affected side. The costal movements are well visualized on the sound side but are absent on the affected side.

a band of gauze is tied over the chest and around the board. Sighting along the prominence of the sternum, the examiner twists the animal slightly to the right or left until, in his judgment, the center of the sternum is perpendicularly above the spinous processes of the thoracic vertebræ. Formerly this alignment was facilitated by a plumb-bob *(E)*, but experience has demonstrated that sighting with the eye results in sufficient accuracy.

The cassette *(C)* is now slipped into the tunnel beneath the aluminum window, the X-ray tube is brought into position perpendicularly above the center of the cassette, and an exposure made. The technical details, of course, vary somewhat, depending upon type of machine, photographic material, and the size of the animal. We have used approximately the following setting: target-film distance, 36 inches; tube current, 100 ma.; tube voltage, 74 K.V.P.; filter, none; exposure time, one-twentieth of a second for small animals, more for heavier ones; Eastman duplitized film; Patterson cleanable intensifying screens.

CHARACTER OF THE EXPERIMENTAL PNEUMONIA

The experimental pneumonias simulated quite closely the lobar pneumonia of man. The onset was sudden and the lesion was lobar in character, spreading from lobe to lobe. There was typical sustained fever, lasting from two, or three, to six, or seven, days, usually terminating abruptly. Examination of lung tissue demonstrated the presence of the main features recognized in human pneumonia.

INCIDENCE OF MEDIASTINAL AND DIAPHRAGMATIC DISPLACEMENT

Of the 105 cases examined, 42 showed some degree of mediastinal or diaphragmatic displacement to the affected side. Of these, 5 have been chosen to illustrate the phenomenon.

Case 1. Dog 14-D. The animal was small, weighing 14 kilograms.

Nov. 17, 1931.—At 8:30 A.M., the animal received an injection of 0.05 c.c. of Type I *Pneumococcus* culture into a bronchus of the right lower lobe. On November 19, in the morning, the animal was very sick and dyspneic, with a white blood count of 35,000 (12,000 normal for this animal).

Fluoroscopic Findings.—Lesion in the right lower lobe, and slight elevation of the right diaphragm, seen only on deep inspiration.

November 20.—The condition was unchanged. A roentgenogram (Fig. 9) showed uniform clouding of the right lower lung field and the heart slightly but definitely displaced to the affected side. At 11 A.M. the animal was killed, the trachea clamped, and autopsy performed.

Findings.—No pleural fluid. Right lung: Lower lobe had a liver-like appearance in consistency, and was completely consoli-

dated. The middle lobe showed alternate areas of consolidation and pneumatization; the upper lobe was normal. Left lung: Normal. Cultures and smears from the right lower lobe showed pure pneumococcus; histologic examination revealed typical lobar pneumonia.

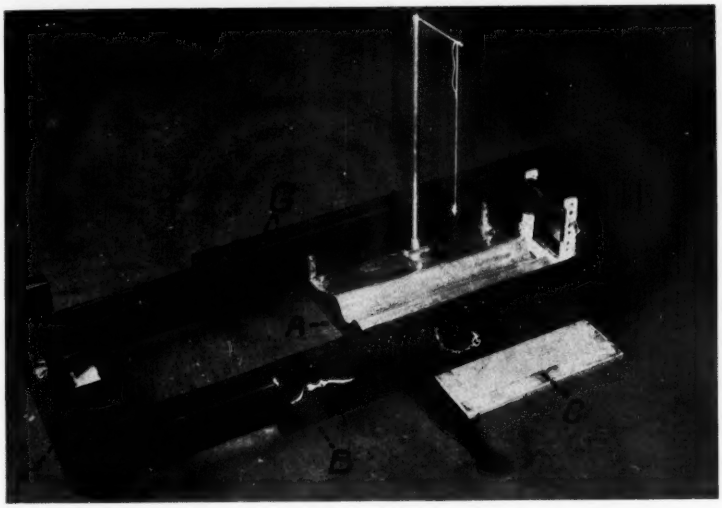


Fig. 8. Special dog board. *(A)* Formed aluminum window bent into a trough to receive the spinal ridge of the dog: *(B)* Line cleats to hold forelegs: *(C)* X-ray film cassette: *(D)* Head restrainer: *(E)* Plumb-bob: *(F)* Wooden posts to hold hind legs: *(G)* Peg which allows the lengthening or shortening of the telescopic sides of the holder to adapt it to dogs of various size.

As first constructed, a plumb-bob was provided, but experience showed that this refinement was not essential since with the spinal ridge fixed in the trough of the aluminum window it was a simple matter to sight along the animal's sternum and position it correctly without the aid of the plumb-bob.

Case 2. Dog 21-D. The animal, which was small, weighed 15.7 kilograms.

Dec. 7, 1931.—At 10:30 A.M., 0.06 c.c. of Type I *Pneumococcus* was injected into the right middle lobe bronchus. On December 8 the animal was very sick and dyspneic, with a temperature of 103.8° F., moderate coughing. Pulse rate, 168; white blood count of 10,000 (6,800 normal for this animal); blood cultures, no growth.

Fluoroscopic Examination.—Frank right middle lobe lesion with possible spread to the upper and lower areas; slight elevation of the right diaphragm and slight displacement of the heart to the affected side. The next day, the animal was very sick, coughing continuously. There was much sputum and nasal discharge, and difficult respiration; white blood count of 23,400; blood culture, negative; temperature 103.9° F.

On December 10, at 10:30 A.M., the condition was the same. A roentgenogram (Fig. 10) showed displacement of the heart to the affected side and slight elevation of the diaphragm on the same side. The animal was killed at 2:30 P.M., the trachea clamped, and autopsy done.

Findings.—No pleural fluid. Right lung: The upper two-thirds of the lower lobe was of a liverish appearance and consistency. The lower one-third contained air. The middle and upper lobes were deep red and consolidated but showed air-containing areas

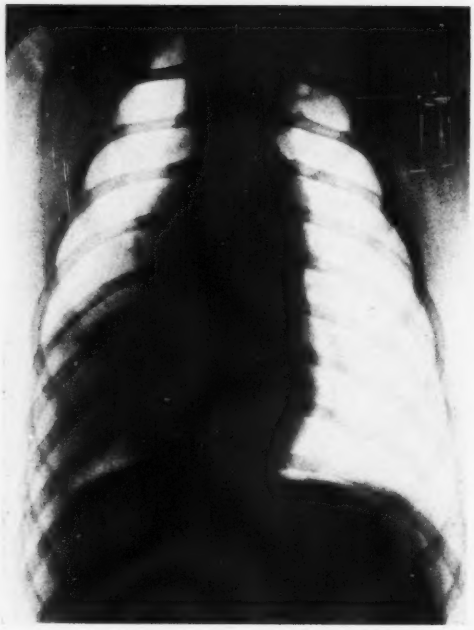


Fig. 9. Case 1, Dog 14-D. Experimental pneumonia of right lower lobe 48 hours after insufflation, with slight displacement of heart to affected side.

Fig. 10. Case 2, Dog 21-D. Experimental pneumonia 72 hours after intrabronchial injection of Type I *Pneumococcus*. Partial consolidation of all of the lobes on the right, elevation of right diaphragm, displacement of heart to the right.

here and there. Left lung: The upper lobe showed several patches of consolidation. The other lobes were clear. Cultures and smears from the right middle lobe showed pure *Pneumococcus*. Histologic examination revealed typical lobar pneumonia in the stage of beginning resolution.

Case 3. Dog 2-C. The animal was small, weighing 9.4 kilograms. At 8:45 A.M., on June 15, 1931, the animal received an injection of 0.05 c.c. of Type I *Pneumococcus* culture into a bronchus of the right lower lobe. The following day, the animal was very sick, and respiration was labored. A roentgenogram (Fig. 11) showed even consolidation of the right lower lobe and the right diaphragm markedly elevated. There was slight displacement of the heart to the right. The animal was killed on June 18, the trachea clamped and autopsy done.

Findings.—Pneumonia of the right lower, middle, and subcardiac lobes in the stage of beginning resolution. Histologic examination revealed typical lobar pneumonia.

Case 4. Dog 40-B. The animal, which was small, weighed 11 kilograms. On April 22, 1931, at 2 P.M., it received an insufflation of 0.03 c.c. of Type I *Pneumococcus* culture into the right upper, and both lower bronchi of the lungs, making a total dosage of 0.09 cubic centimeter. The animal looked sick the next day and the temperature was slightly elevated. The white blood count was 20,000 (11,000 normal for this animal). A roentgenogram (Fig. 12-*A*) showed slight clouding in the right upper and both lower areas. The heart and diaphragm were normal in position.

On April 24 the condition was the same.

A roentgenogram (Fig. 12-*B*) showed heavy clouding in the right upper lobe, but the clouding in both lower lobes had practically disappeared. The mediastinum and the heart were displaced toward the right side in the upper area. The animal died on April 26, and autopsy was performed.

Findings.—No pleural fluid. Right upper lobe showed fairly even consolidation. Right and left lower lobes showed several small nodular consolidated areas. Smears from the right upper and both lower lobes showed pneumococci and small Gram-negative bacilli. Histologic examination revealed typical lobar pneumonia of the right upper lobe. The nodules of the lower lobes showed an atypical inflammatory process.

Case 5. Dog 20-B. The animal was small, weighing 10 kilograms. On Dec. 15, 1931, at 10 A.M., it received 0.35 c.c. of Type I *Pneumococcus* culture into the left lower lobe bronchus. On December 16 the animal appeared somewhat sick, and had a slight cough. The white blood count was 18,000 (7,800 normal for this animal).

Fluoroscopic Findings.—Lesion in the left lower lobe. Left diaphragm slightly elevated. The heart was displaced toward the left. A roentgenogram (Fig. 13-*A*) confirmed the fluoroscopic examination.

On December 17, the condition was much improved, the temperature was 102° F., and there was no cough. By December 19, the dog had completely recovered. A follow-up roentgenogram (Fig. 13-*B*), made on January 4, showed clear lungs and normal position of the heart and diaphragm.

ANALYSIS OF 40 CASES OF LOBAR PNEUMONIA IN HUMAN SUBJECTS

Of the patients, 37 were adults and three children. Of the cases, 22 show definite elevation of the diaphragm and five demonstrate some degree of displacement of the heart or mediastinal structures to the affected side. It seems possible to make the following generalizations:

Fig. 11. Case 3, Dog 2-C. Experimental pneumonia of right lower lobe 24 hours after injection. Note elevation of right diaphragm and slight displacement of heart to the right.

1. Diaphragmatic elevation and mediastinal displacement are to be noted only at full inspiration. At expiration, the findings are normal.

2. Displacement begins early, sometimes before it is possible to demonstrate consolidation, and persists usually throughout the course of the disease. It sometimes continues for a period after complete resolution has occurred.

3. Displacement is greatest and most regularly present when one entire lung is involved. It is less extensive and less frequent when the pneumonia involves only the lower lobe, and of slight degree or quite absent in simple upper lobe lesions.

4. In children and experimental animals, the heart or other mediastinal structures are apt to be displaced; in adults, most of the compensation is accomplished by the diaphragm.

5. Neither mediastinal displacement nor diaphragmatic elevation is so regular or extensive in lobar pneumonia as it is in massive atelectasis.

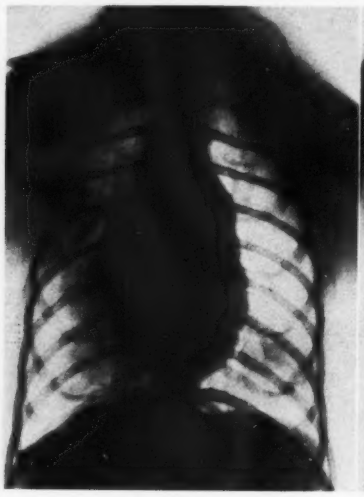


Fig. 12-*A*. Case 4, Dog 40-B. Experimental pneumonia 24 hours after insufflation of Type I *Pneumococcus* culture into right upper and both lower lobes. Normal position of heart and diaphragm.

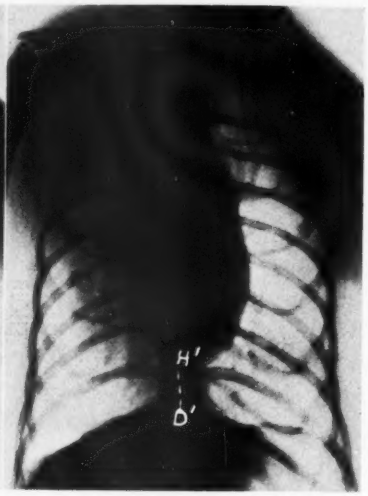


Fig. 12-*B*. Case 4. Forty-eight hours after injection. Marked clouding in right upper lobe. Displacement of mediastinum including heart toward the lesion. The distance between the cardiac apex and the diaphragmatic dome *(H'-D')* had definitely increased as compared with the earlier film, apparently resulting from the pulling of the heart by the lesion in the right upper lobe.

DISCUSSION

It seems clear that, in the pneumonia of human beings as well as that of experimental dogs, the volume of the affected lung is smaller than normal at inspiration, as a result of which compensatory displacement of the mediastinum, or diaphragm, or both, occurs. In adults, it is usually the diaphragm alone that responds to the decreased lung volume; in children and dogs, the more flexible mediastinum participates in the compensatory contraction of the thoracic cavity.

A recognition of this condition may be of assistance in differential diagnosis. For instance, the roentgenogram of a patient suspected of having pneumonia may show no pulmonary consolidation, but elevation of the hemidiaphragm on the suspected side may be the single clue to a small pneumonic patch hidden by the heart or by the dome of the diaphragm. Differentiation between pneumonic consolidation and pleural effusion is definitely simplified if mediastinal or diaphragmatic displacement can be demonstrated: in effusion, the displacement is away from the lesion; in pneumonic consolidation, it is toward the affected side. On the other hand, it is by no means an easy matter to differentiate between a diaphragm elevated because of the decreased volume of a consolidated lung and one pushed up by subphrenic abscess. In general, the elevated diaphragm of pneumonia presents a smooth upper surface and, though excursion is decreased, it is seldom entirely absent. But

TABLE I.—SUMMARY OF 40 CASES OF PNEUMONIA

Case no.	Unit no.	Name	Roentgenologic findings		Final clinical diagnosis
			Pneumonia	Visceral shift	
1*	18507	H. P.	W. L., R. L.	D., T., H.	Lobar pneumonia, Type IV
2*	16891	E. Z.	L. M., L. L.	D., T., H.	Lobar pneumonia, Type I
3	18425	A. C.	R. M., R. L.	D., T., H.	Lobar pneumonia, Type II
4†	49904	J. K.	W. R.	Diaphragm	Massive pneumonia
5†	42557	A. W.	L. L.	Diaphragm	Post-operative pneumonia
6	21542	R. B.	R. M., R. L.	Diaphragm	Lobar pneumonia, Type II
7	3193	M. K.	R. M., R. L.	Diaphragm	Lobar pneumonia, Type II
8	10778	H. L.	R. L.	Diaphragm	Lobar pneumonia, Type II
9	18748	A. L.	R. L.	Diaphragm	Lobar pneumonia, Type I
10	9624	A. M.	L. L.	Diaphragm	Lobar pneumonia, Type I
11	18273	H. M.	R. M.	D., T., H.	Lobar pneumonia, Type I
12*	6817	R. M.	R. L.	Diaphragm	Lobar pneumonia, Type III
13	21365	W. S.	R. M., R.L.	Diaphragm	Lobar pneumonia, Type IV
14	11423	F. V.	R. L.	Diaphragm	Lobar pneumonia, Type IV
15*	6340	T. F.	R. M., R. L.	Diaphragm	Lobar pneumonia
16†	47314	F. P.	R. L.	Diaphragm	Post-operative pneumonia
17	35300	E. C.	R. M.	Diaphragm	Lobar pneumonia, Type III
18	36001	S. T.	W. R.	Diaphragm	Lobar pneumonia
19*	48751	M. H.	B. L.	Trachea, heart	Pneumonia, hemorrhagic
20†	49210	M. E.	R. L.	Diaphragm	Lobar pneumonia, Type II
21	3971	A. Z.	R. L.	Diaphragm	Pneumonia, Type IV
22†	52695	M. R.	L. L., R. L.	Diaphragm	Lobar pneumonia, Type II
23	33971	A. P.	R. M.	Diaphragm	Lobar pneumonia
24	19487	T. A.	L. L.		Lobar pneumonia, Type I
25	10186	L. B.	L. L.		Lobar pneumonia, Type II
26	9136	S. H.	L. L., R. L.		Lobar pneumonia, Type III
27*	18620	V. C.	R. L., R. M.		Lobar pneumonia
28	10059	M. R.	L. L., R. M.		Lobar pneumonia, Type II
29	21212	B. G.	L. L.		Lobar pneumonia, Type II
30*	20033	N. H.	L. L.		Lobar pneumonia, Type IV
31	6429	K. H.	W. R.		Lobar pneumonia, Type III
32	10990	J. L.	R. U., R. L.		Lobar pneumonia, Type I
33	10367	M. M.	L. U., L. L.		Lobar pneumonia, Type II
34	12075	N. S.	L. L., R. M.		Lobar pneumonia, Type II
35	17747	F. T.	L. L.		Lobar pneumonia, Type III
36	8292	L. H.	L. L.		Pneumonia, Type IV
37	24810	C. B.	R. L.		Acute lobar pneumonia
38	30697	J. L.	R. M.		Lobar pneumonia, Type III
39	29237	B. H.	W. R.		Lobar pneumonia
40*	8763	E. K.	W. R.		Lobar pneumonia

Key to characters.—B. L.—Both lungs
W. R.—Whole right
W. L.—Whole left
R. U.—Right upper
R. L.—Right lower
R. M.—Right middle
L. U.—Left upper
L. L.—Left lower
L.M.—Left middle
D.—Diaphragm
T.—Trachea
H.—Heart
*—Clinical diagnosis confirmed by autopsy
†—Double exposure roentgenogram

many workers (10, 11) believe that, in subphrenic abscess, the elevated diaphragm is distorted either by flattening or local bulging. Furthermore, they believe that the diaphragm is immobilized and that the lung above it usually shows some evidence of compression.

My assumption—that decreased volume

of the affected lung explains the diaphragmatic and mediastinal displacement of pneumonia — is somewhat at variance with certain views that have been expressed by others. Thoenes, Wallgren, and Griffith believe that overdistention of the healthy lung is the cause. In a sense this is true, though it seems probable that this overdistention on the normal side is a simple mechanical result of increased elastic tension of the affected lung. Van Allen and I inflated the excised lungs of a dog which had died of experimental pneumonia and found, as we expected, that, when pressure was applied to the trachea, the normal left lung distended much more than the consolidated right lung.

Fig. 13-*A*. Case 5, Dog 20-B. Twenty-four hours after insufflation of *Pneumococcus* culture into left lower bronchus. Displacement of the heart to the left and slight elevation of diaphragm on the affected side.

Fig. 13-*B*. Same animal as shown in Figure 13-*A*. Control roentgenogram taken 19 days after injection. Disappearance of pneumonia in left lower lobe. Heart and diaphragm have returned to normal position.

Fig. 14-*A*. Both lobes collapsed: the right pneumonic lobe is slightly larger than the left normal lobe.

Fig. 14-*B*. Same lobes applied with equal pressure of air. The pneumonic right lobe is much smaller than the normal left lobe.

It is, of course, a common autopsy observation that pneumonic areas do not expand on inflating excised lungs.

Coryllos and Birnbaum have assumed that massive atelectasis was present in these cases of pneumonia. It is true that atelectatic patches are sometimes present in the lungs of experimental animals (1, 12) and may possibly aid in producing some of the mediastinal and diaphragmatic displacement we have described, but it is our opinion (1) that they are at most of minor importance. We believe that an increased lung elasticity, due to thickening of the alveolar and lobar septa and pleural membranes, is the underlying factor.

SUMMARY

In 40 consecutive cases of lobar pneumonia in human subjects, mostly adults, five showed displacement of the heart and trachea to the affected side and 22 elevation of the diaphragm on the affected side. All of the five cases in the group studied by the double-exposure method showed diminished diaphragmatic and costal excursion on the diseased side. In 105 cases of experimental pneumonia in dogs there were 42 instances of visceral displacement.

CONCLUSIONS

1. The consolidated lung of lobar pneumonia has a higher elastic tension than normal; as a result, it expands less than the normal on full inspiration.

2. To compensate for decreased lung volume at full inspiration, there is usually some visceral displacement to the affected side.

3. In experimental animals or children, the mediastinum is the structure most active in compensating for decreased lung volume; in adults it is usually the elevated diaphragms that accomplish the compensation.

4. Roentgenographic demonstration of mediastinal or diaphragmatic displacement toward the affected side in cases of pulmonary disease is sometimes an important factor in differentiating between lobar pneumonia, pleural effusion, and certain other diseases.

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THE TECHNIC OF INTRAVENOUS UROGRAPHY

AN APPARATUS AND A METHOD OF COMPRESSING THE URETERS, USED IN 411 CASES

By JACOB ABOWITZ, M.D., Department of Roentgenology, Cedars of Lebanon Hospital, Los Angeles, California

THE diagnostic value of intravenous urography is at present still underestimated, due to the failure to obtain a greater proportion of cases in which the urinary tract is filled and visualized on the film. The causes of the failure of filling of the urinary tract are either faulty technic or anuria, very often the result of an acute renal colic or cystoscopy. In acute renal colic a good readable film is often obtained several hours after the injection of the drug. In the case of cystoscopy, on the other hand, we postpone the injection for three days, or until the normal urinary excretion is estab-

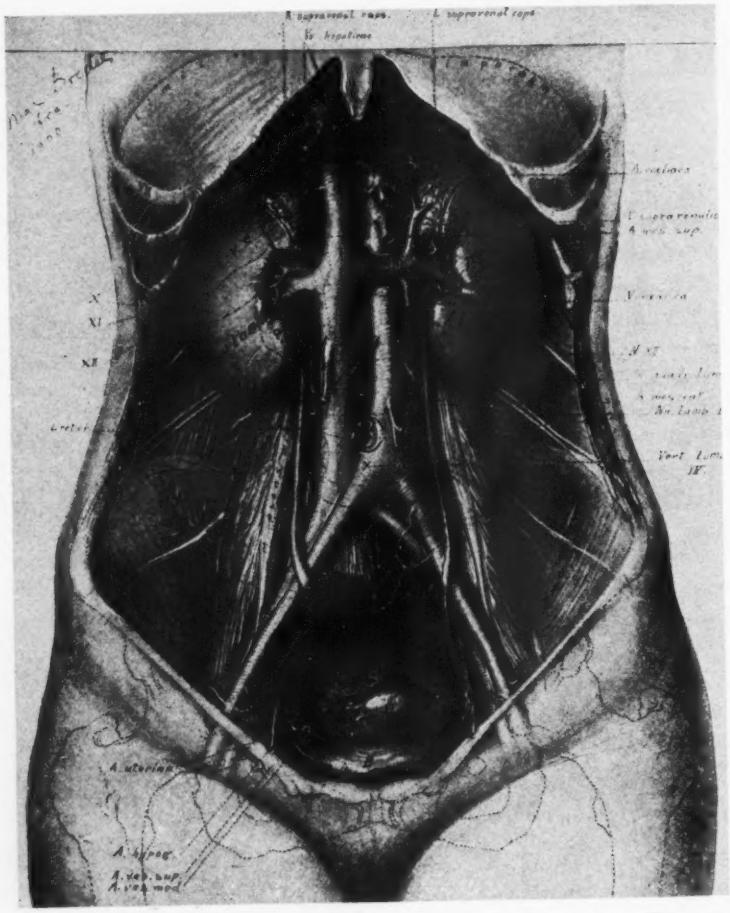

Fig. 1. Showing the relation of the ureter to the iliac artery. The compression is applied at the point of crossing.

lished. In order to avoid loss of time, we, therefore, recommend that the intravenous method precede the retrograde method.

The secret of success in obtaining a greater number of readable films lies in the method of compression used before the X-ray exposure. The compression is applied over the lower abdomen at a point at which the ureter crosses the common iliac artery. According to Cunningham's "Anatomy," "The ureters lie in front of the termination of the common iliac arteries at the level of the intertubercular plane and about 1.5 inches from the median plane" (Fig. 1).

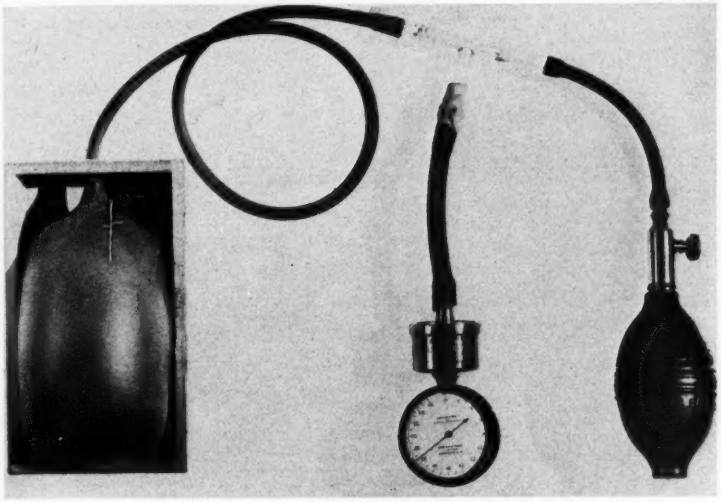

Fig. 2. The several parts of the compressing apparatus.

The apparatus used for compression consists of the following parts (Fig. 2):

1. A small wooden box, $5 \times 3 \times 1.5$ inches, with one side open.
2. A small rubber bag, 4×2.5 inches, with a rubber tube attached to it.
3. A monometer, dial type.
4. A rubber bulb, such as used in a sphygmomanometer.
5. A "T" glass connection.

The patient is in either the supine or the upright position. The wooden box, holding the rubber bag, is placed, open side down, over the lower abdomen, about 4 inches proximal to the symphysis pubis. The long axis of the box, transverse to the long axis of the body, is held snugly in position by the compression band of the Bucky diaphragm. The three ends of the "T" tube connect, respectively, the rubber tube of the bag, the monometer, and the rubber bulb. The rubber bag is then inflated till a pressure of about 180 mm. of mercury is registered, the pressure being maintained for five minutes, after which an exposure is made. The entire urinary tract proximal to the compression is then invariably filled and a readable film is thus obtained. Another film is exposed immediately after the compression is removed. On the second film the urinary tract distal to the compression is visualized.

TECHNIC IN DETAIL, CHARACTERISTIC FINDINGS

The first film is taken before the injection. The exposure is made ventrodorsally with the patient in the horizontal posture on deep expiration. This film demonstrates

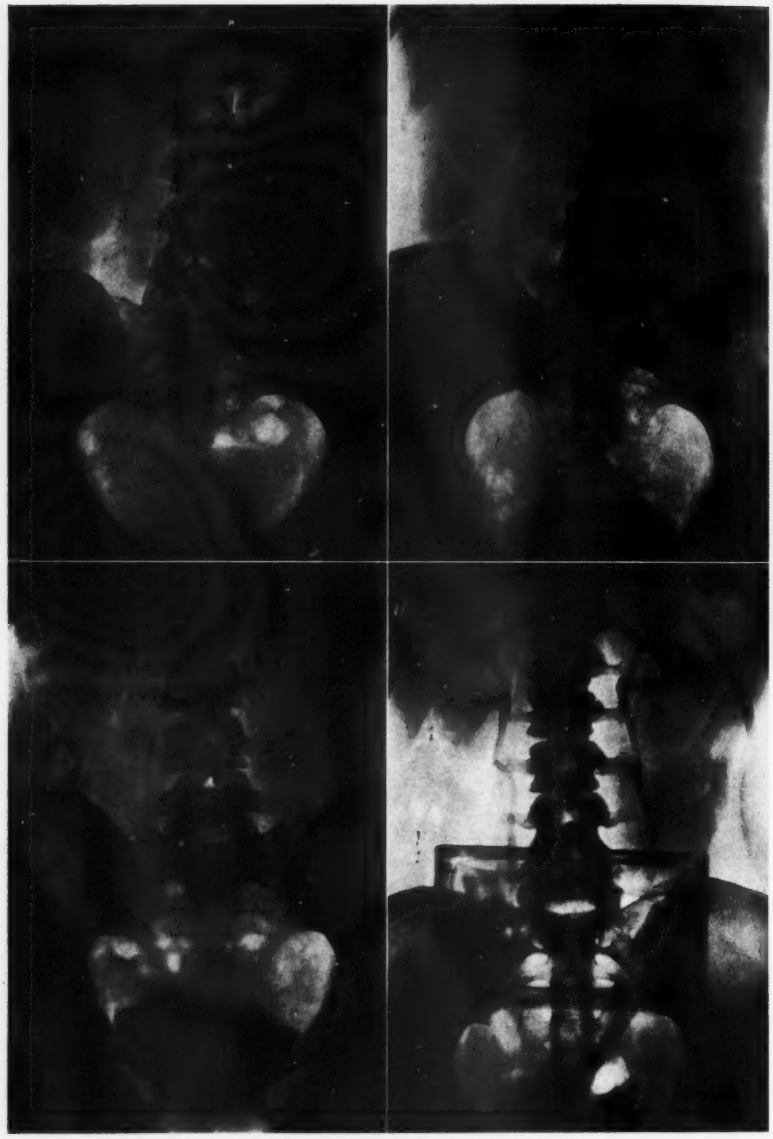

Fig. 3 *(Upper left).* Before the injection. Notice the calculus in the region of the right upper minor calyx, which might have been obscured by the excreted drug after the injection. This film also shows the position of the kidney during deep expiration.

Fig. 4 *(Upper right).* Five minutes after the injection. The film shows the appearance time of the excreted drug. Notice the increased intensity of the shadow of the renal pelvis on the right side, compared with that of the left. It is due to a partial obstruction at the ureteropelvic junction.

Comparing it with the previous exposure, the film also shows the position of the kidney on deep inspiration, or the excursion of the kidney during deep respiration.

Fig. 5 *(Lower left).* About 30 minutes after the injection. The urinary tract is more radiopaque. Notice the shelf in the urinary bladder, formed by the pressure of an enlarged uterus.

Fig. 6 *(Lower right).* Fourth film, taken in the horizontal posture, shows the compression apparatus *in situ.* Notice the filled urinary tract proximal to the compression.

Fig. 7. Fifth film, taken immediately after the compression has been released, showing the filled ureters, distal to the compression.

Fig. 8. Sixth film, with compression in the upright posture. It shows whether or not a ptosed kidney can be raised by compression.

existing calculi or calcareous deposits which may be obscured by the excreted drug. It also shows the position of the kidney during deep expiration. It is advisable that the patient remain on the X-ray table in the supine position during the injection and until the third exposure is made. Keeping the patient quietly in this position tends to keep the urinary tract filled (Fig. 3).

Five minutes after the intravenous solution is injected the second film is made, on deep inspiration. It shows the appearance time, the difference in the intensity of the shadows of the excreted drug between one side and the other, and the position of the kidney during deep inspiration (Fig. 4).

A third film is made 30 minutes after the injection, during suspended respiration. In addition to a denser shadow of the urinary tract, the film shows the outline of the filled urinary bladder. It often demonstrates diverticula of the bladder, a thickened bladder wall, trabeculation, or an enlarged prostate. In the female, it shows extrinsic pressure on the bladder produced by adjacent pelvic organs. The size, shape, and position of the uterus and tumors of the uterus and adnexa are often recognized by the indentations they produce on a filled bladder. For that purpose we often make an additional film of the filled bladder in the upright posture (Fig. 5).

Before the fourth film is made, the patient is directed to empty his bladder. The exposure is made ventrodorsally with the patient in the horizontal posture and on suspended respiration. Compression is then applied before the exposure, as previously described. Besides visualizing the upper urinary tract, down to the point of compression, it shows the amount of residual urine in the bladder (Fig. 6).

Fig. 9. Film made after the patient had walked the floor several times. Notice the nephroptosis on both sides and the hydronephrosis revealed by the urinary stasis in the renal pelves in the upright posture.

The fifth film, made immediately after the compression has been removed, shows the ureters distal to the compression (Fig. 7).

The sixth film is made with compression similar to the fourth exposure, the only difference being that the exposure is made in the upright posture. This exposure demonstrates whether or not a ptosed kidney can be raised, by compression, to its original position (Fig. 8).

Before the last, or seventh exposure, the patient is directed either to walk the floor several times or to stand on his toes and come down forcefully on his heels to shake the kidney down, so that the degree of nephroptosis in the upright position is demonstrable on the film. The film, taken in the upright posture, also shows, in cases of hydronephrosis, the amount of urinary stasis in the pelvis and ureters (Fig. 9).

SUMMARY

1. The value of intravenous urography as a diagnostic procedure in the examination of the urinary tract is at present underestimated.

2. Among other causes of non-visualization of the urinary tract, poor technic is a great factor.

3. A workable technic and an apparatus for compressing the ureters is described.

Study Throws New Light on Tooth Decay.—The enamel which protects our teeth is made up of thousands of minute crystals of apatite, a kind of phosphate of calcium. In a dog's teeth these minute crystals are arranged perpendicular to the surface, while in human teeth they are inclined, according to findings of J. Thewlis, of the Physics Department, National Physical Laboratory, Teddington, England.

A dog's teeth are almost immune from caries. Chemically their constituents are identical with those of human teeth and possibly it is their physical structure that gives them increased resistance.

To observe crystalline structure by means of X-rays a different method is used from that of the dentist who takes X-ray films to see the shape of the roots. The X-rays come from a point source; they strike at a known angle and are scattered in definite directions. The films obtained consist of dots and rings, and much mathematical sleuth work is needed to interpret them in terms of the arrangement of atoms and crystals.—*Science Service.*

THE SPECTROPHOTOMETRIC ANALYSIS OF THE COLOR OF THE SKIN FOLLOWING IRRADIATION BY ROENTGEN RAYS[1]

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ROCHESTER, MINNESOTA

THE change in the color of the skin, that is, the production of erythema, has been used as an index of the dosage of roentgen rays since the realization that the tolerance of the skin for these rays is not unlimited. So far as is known, attempts have never been made to analyze accurately by physical means this change of color.

The usual conception of the roentgen erythema is that it is a gradually increasing redness, reaching a maximum on or about the fourteenth day, gradually declining thereafter with the coincident, or subsequent, development of pigmentation. Such a statement does not permit of a precise description of the color reaction and no one, from such a description, could reproduce a similar color.

In 1920, Seitz and Wintz concluded from their investigations that the roentgen erythema of the skin was satisfactory for use as a unit of standardization. They stated that the reaction in the normal skin varied only from 10 to 15 per cent with the same dose in different individuals. Leddy and Weatherwax disagreed with these observations, stating that the erythema, if taken as a unit, is flexible, arbitrary, and inaccurate. This statement has been substantiated by others (2) and is now generally accepted. Following the work of Failla with radium, Leddy and Weatherwax suggested the use of the threshold erythema as a unit in roentgen treatment if cutaneous erythema was to be used. Threshold erythema is defined as the erythema which is produced from a dose of roentgen rays necessary to cause perceptible reddening in from seven to fourteen days in 80 per cent of subjects irradiated. Such a unit allows for normal variations, yet is, at the same time, rather definite.

Until recently, no attempt has been made to express the color of the normal skin in terms of its attributes, which are brilliance, or relative luminosity, hue, or dominant wave length, and saturation, or purity. Unless color is described according to its attributes, nothing definite is stated with regard to the color. It would seem that a more accurate description, other than clinical observation, of the change in the color of the skin following roentgen irradiation would be of value in outlining the course of the erythema. Such a problem entails consideration of some of the fundamentals of color and of the methods of analyzing color.

COLOR AND ITS ATTRIBUTES

Fundamentally, color is an impression produced on the observer when the retina is stimulated by light. Under varying conditions, a material will transmit or reflect a different amount of light. The source, quality, and intensity of light introduce variations. The most significant variable factor is the condition of the observer's color vision, particularly the presence, or absence, of color blindness. It is improbable that two individuals will react in the same degree to the same stimulus.

Various tintometric, or colorimetric, methods for the measurement of color have

[1]The material in this paper was submitted by Dr. Harris to the faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Roentgenology. The work was done in the Division of Physics and Biophysical Research.

been developed. Such methods, which utilize color plaques made to certain specifications, are capable of being analyzed by the Munsell spinning disk or the Bradley top. These systems are open to the objection that they do not analyze the spectral colors reflected or transmitted from the material but use a set of arbitrary pigment standards. These standards have the further objectionable characteristic of fading with time. As in the direct observation of color, the personal factor enters, although the accuracy is greater. Such systems have been applied to the study of the color of skin by Rowntree and Brown, Freund and Novak (8, 9), and others, representing a valuable contribution to clinical medicine.

On the other hand, the spectral colors of white light can be measured easily and can be standardized. Any color of a given wave length, such as sodium yellow at 592 mμ, is always the same and can be reproduced exactly. Not only do pigments vary in composition, but the light transmitted or reflected is not a pure spectral color, being a combination of different sets of wave lengths (20).

The report of the Committee on Colorimetry of the Optical Society of America (31) has greatly simplified the subject of colorimetric measurements. In this report, certain fundamental statements are set forth. Color is defined as the general name for all sensations arising from the activity of the retina and its attached nervous mechanism. Such activity, if the individual is normal, is nearly always a specific response to radiant energy of certain wave lengths and intensity. "Color cannot be identified with or reduced to terms of any purely physical conception; it is fundamentally a psychologic category." The spectrum is regarded physically as a graphic representation of radiant energy of certain wave lengths or frequency. The unit of measurement is the millimicron, a thousandth of a micron, or a millionth of a millimeter. The Ångström unit (Å.) which is frequently used, is one-tenth of a millimicron.

The human eye is sensitive only to a short range of radiant energy in the physical spectrum. This range is in the region lying between 400 and 760 mμ, varying in the extremes with certain individuals. Beyond the red end of the physical spectrum lie the infra-red rays; their effect on consciousness is a sensation of heat. Beyond the violet end of the spectrum are the ultraviolet rays; their effect is realized by chemical or photo-electric reactions.

The color of any material depends on the absorption of certain wave lengths and the reflection or transmission of others. When one speaks of an object as being red, only the wave lengths in the red end of the spectrum (and certain others, according to Munsell) are reflected or transmitted, while the others are absorbed. When no light is reflected or transmitted and all is absorbed, the object is colorless, or black. If all the light is transmitted or reflected, the object is transparent, or white. If more or less equal proportions of all visible wave lengths are absorbed, the color is gray, or one of a series between black and white.

According to the work of Maxwell and others, all colors of the visible spectrum may be represented in terms of three primary colors: red, green, and violet. Such primary colors were considered by Young (1), as incapable of being matched by mixtures of any other colors. Pure spectral colors were obtained by the use of prisms and a source of white light. Later Maxwell showed by calculations that stimulation of one or more of the three sensations could account for all colors.

An adequate description of color can be made only by specifying it in terms of its three attributes. Such a specification takes the form of an immediate description of the color, without any reference to the stimulus.

Relative luminosity, or brilliance (brightness, value, tint, visual brightness), is that attribute of any color in respect to which it may be classified as equivalent to some member of a series of grays ranging between black and white. Brilliance, or relative luminosity, is absolutely necessary if color is to exist at all. Hue, or dominant wave length, is that attribute by which color is classified as reddish, yellowish, greenish, or bluish, differing in that respect from a gray of the same brilliance. Purity, or saturation, is that attribute which determines how different the hue is from a gray of the same brilliance. If a color has hue, it also has saturation, and *vice versa;* the two are interdependent. Hue is qualitative, while saturation is quantitative. Hue and saturation determine the sensation produced when "color" is used in the common and usual meaning of the word, gray and black being colorless by this definition. When hue and saturation only are taken into consideration, "chroma," as suggested by the Committee on Colorimetry of the Optical Society of America, is a better term than "color."

SPECTROPHOTOMETRY AND COLOR OF SKIN

Spectrophotometry offers a means of satisfactorily analyzing colors. It is the fundamental basis of all color specification (10) and the most accurate method available at the present time. The attributes of a color analyzed by the spectrophotometer are definite, describing the color absolutely and completely. By the use of a water-cooled cell, devised by Brunsting and Sheard (4), colors of living materials can be analyzed. Such a method of analyzing the color of the skin is final.

By spectrophotometric means, the attributes of color are determined independently of the condition of the observer's sense of color vision and independently of the source of light, provided this is sufficiently intense to make readings possible at the ends of the visible spectrum.

Sheard (27), and Sheard and Brown (28) were the first to use the spectrophotometric data supplied by the Committee on

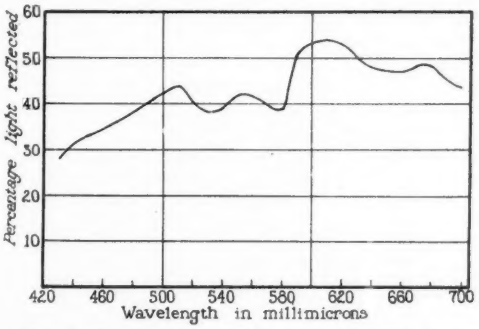


Fig. 1. Spectrophotometric curve obtained by reflection from the skin.

Colorimetry of the Optical Society of America to analyze the color of the skin. Their particular researches related to pathologic as well as to normal skin. In normal subjects, they found that the dominant wave length (hue), purity (saturation), and percentage red, green, and violet excitation values remained fairly constant, but that the values of relative luminosity (brilliance) decreased with increased amounts of pigment. They found the highest values of the relative luminosity in the skin of blond persons, the lowest values in the skin of the negro, with the brunette intermediate. Such a conclusion is almost self-evident, for a person with much pigment in the skin will not reflect as much light as one with only a small amount (30).

In numerical values, Sheard and Brown found the dominant wave length (hue) to be about 585 mμ, the purity (saturation) approximately from 40 to 45 per cent, and the relative luminosity (brilliance) between 45 per cent in the blond and 17 per cent in the negro.

Subsequently Brunsting and Sheard (5, 29) analyzed the color of the skin of blonds and brunettes and of persons of different races to determine the variations in color due to pigmentary content of the skin.

They found that the dominant wave length (hue) and purity (saturation) remained constant but that the relative luminosity (brilliance) decreased inversely with the amount of pigment in the skin. They found in certain regions of the visible spectrum. Such zones of decreased reflection were more evident when the area of skin under consideration was congested; the minimums occurred in the regions 540 and 580 mμ and

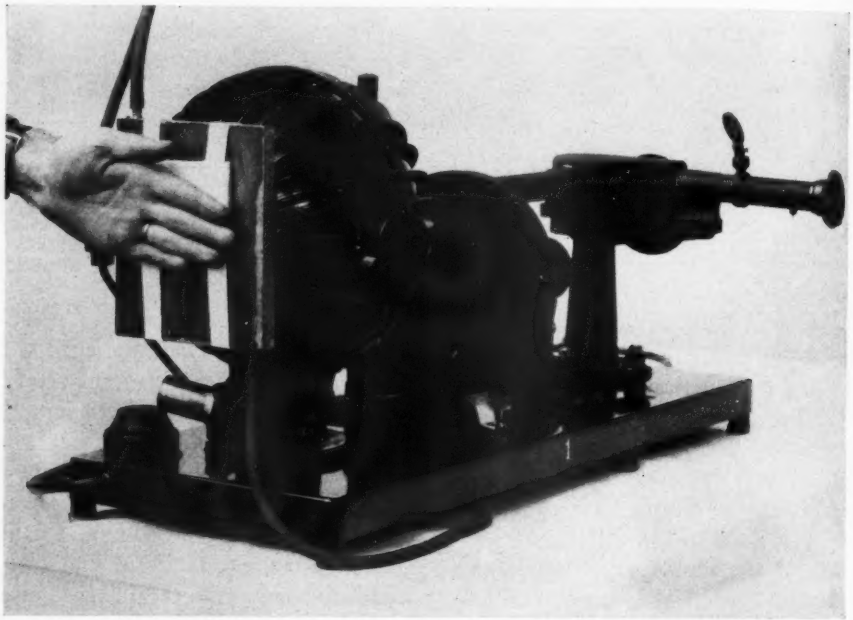


Fig. 2. Spectrophotometer, or color analyzer, with water-cooled cell in position.

that variations in pigment did not affect the dominant wave length (hue) or purity (saturation). They found that the difference in color of the skin in different portions of the body depended only on the variations in relative luminosity (brilliance), except in exposed areas in which there was congestion of the superficial vessels. When the vessels were congested, the hue and saturation changed. They suggested that the pigment in the skin served to protect the underlying structures from excessive luminous energy.

In the portion of their work dealing with this phase of the subject Brunsting and Sheard (6) found that the blood in the superficial capillaries exerted a marked influence on the color of the skin. They noted a decrease in the percentage of reflected light corresponded to the absorption bands of oxyhemoglobin (Fig. 1). As shown in two postmortem specimens analyzed after the blood was removed, these zones of absorption of light tended to disappear when the skin was devoid of blood. They also found that, when the skin was abnormal, an abundance of oxygenated blood near the surface caused a shift of the dominant wave length (hue) toward the red end of the visible spectrum (640 millimicrons). When a condition of cyanosis obtained, in which reduced hemoglobin predominated in the superficial vessels, the dominant wave length shifted toward the blue end of the visible spectrum (490 to 500 millimicrons). By spectrophotometric methods, they were able to detect changes in the color of the skin

when the hand was held above or below the level of the heart, thus showing the effects of anemia and congestion, respectively.

low, and *vice versa*) and that the difference in color of the skin of different individuals or races or different portions of the body

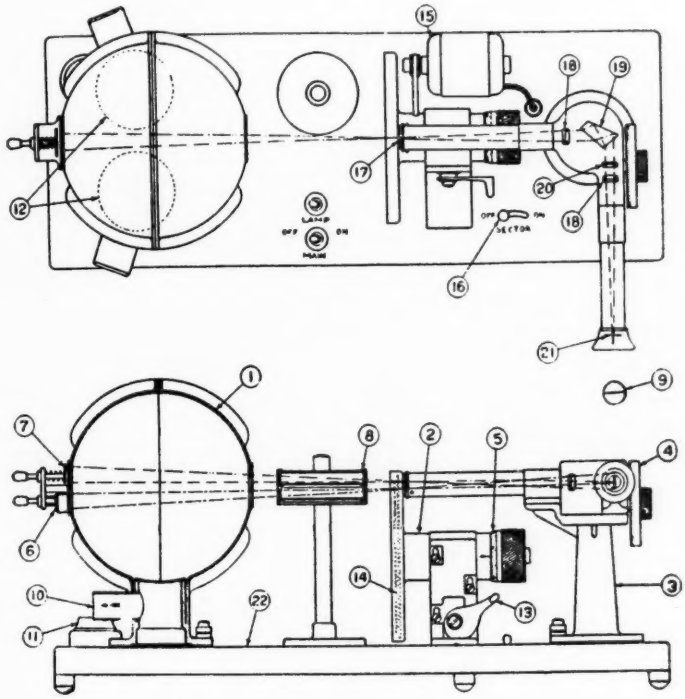


Fig. 3. Cross-sectioned diagrams showing the working parts of the spectrophotometer: 1, spherical lamp house; 2, photometer; 3, spectrometer; 4, wave length scale; 5, photometric scale; 6, holder for standard sample; 7, holder reflection samples; 9, field of view through the eye slit; 14, sector disks; 17, entrance slit; 19, dispension prism, and 20, biprism.

From this work it is evident that the spectrophotometer furnishes the most satisfactory means of studying the color of the skin, that the dominant wave length (hue) of the skin is in the region of spectral yellow (580 to 590 mμ), that the purity or saturation of this hue remains constant, that the relative luminosity or brilliance depends on the pigment content of the skin, that the changes in the red, green and violet excitation values vary in a linear fashion, with the percentage green acting as a turning point (that is, when the red is high the violet is depends on the difference in relative luminosity (brilliance).

EARLIER WORK ON THE COLOR OF THE SKIN FOLLOWING ROENTGEN IRRADIATION

In considering the color of the skin following roentgen irradiation, there has been, as far as we could determine, no attempt to analyze the color except by direct visual observation. Therefore, no adequate description of the color or of the course of the color or its variations has been offered. No mention has been made of the attributes of

color in terms of hue, saturation, and brilliance.

A few months after Roentgen's announcement, in December, 1895, of the phenomenon bearing his name, there appeared

Holzknecht, in 1903, described a "premature reaction," occurring in some cases within from a few hours to a few days after exposure, then disappearing, to be followed by the "true reaction" on or about the elev-

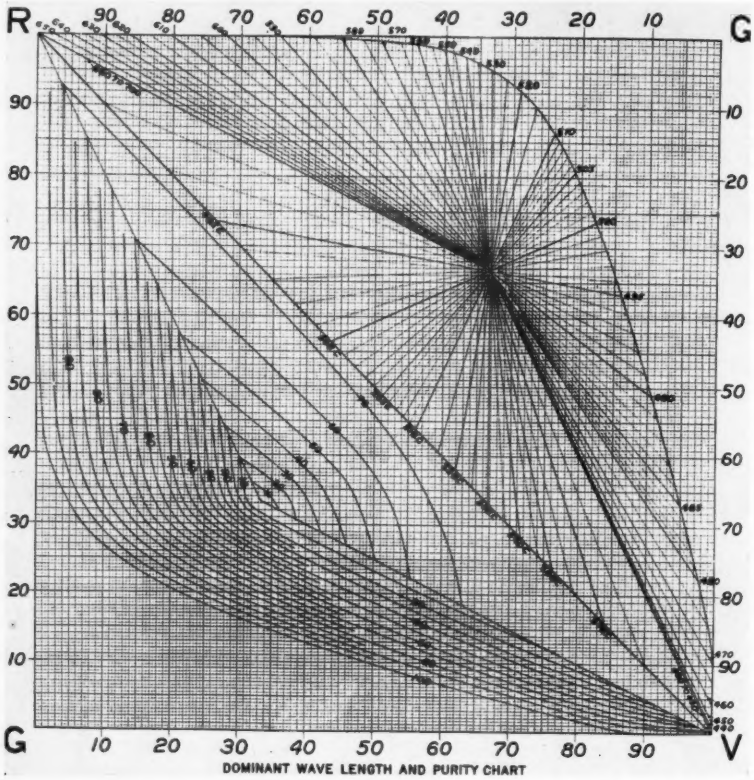


Fig. 4. Dominant wave length and purity charts from which the hue and the degree of saturation may be computed by the use of the data obtained from the values of the color excitations.

all over the world machines for generating roentgen rays. Since, at first, the small output of these necessitated exposures lasting for hours, it was not long before there appeared many reports of effects on the skin. Leppin was the first to describe these effects. As an engineer installing and demonstrating apparatus, his hands were exposed frequently, erythema developed, and the subjective sensation of heat was followed by thinning of the skin.

enth day. Holzknecht believed that this premature reaction was due to the roentgen rays and that it intensified the later occurring true reaction. Köhler, who was the first to describe the premature reaction, thought it due to heat waves from the tube. Schmidt considered that it was due to the ultra-violet waves from the tube and called the resulting pigment "pseudo pigment." In 1911, Brauer reviewed the subject and concluded that the reaction was part of the

true roentgen effect; that its intensity was proportional to the intensity of the roentgen rays, and that the pigment changes following it were due to an effect on the pigment itself.

From this earlier work it is evident that two portions of the roentgen reaction were known: an erythema occurring within one or two days, and another beginning on the fifth or sixth day and reaching its maximum on about the fifteenth day.

In 1923, Miescher (18), who answered in the affirmative his own question: "Is the roentgen reaction in the skin a rhythmic phenomenon?" described waves of erythema between eight and 22 days, 32 and 51 days, and after 58 days, respectively. In a much more comprehensive article, he described a complete experiment on the clinical determination of the course of the erythema due to irradiation with roentgen rays.

Miescher (19), who observed numerous patients, divided his technic into four qualities of rays, using on these patients five or six different doses of each quality of ray. He used an area 4×4 cm. on the thigh for a field. He then observed the skin reaction daily and recorded the changes in the color of the skin. His observations were made under as standard conditions as possible for the source of light, and so forth. They were, however, clinical observations of the difference of color of the irradiated area as compared to the surrounding normal skin. As a scale of the erythema he used R1, a slight redness, to R7, ulceration. The pigmentary changes he graded from P1, slight pigmentation, to P4, marked pigmentation.

Miescher's results showed a wave-like course of the erythema, with a wave occurring between the first and fourth days (average, two days). Another wave occurred between the eighth and twenty-second days (an average of 15 days). A third wave occurred between the thirty-fourth and fifty-first days (an average of 39 days). He described the third wave as the most intense. His charts show the third wave to be the highest in value. The latent period between waves, which was apparent rather than real, tended to disappear with heavier doses. The crests of the waves tended to remain in the same time-relations, but were higher or lower according to the intensity of the dose. There were individual variations of from 15 to 20 per cent in the time-relation of the crests of the waves and from 40 to 50 per cent variation in the troughs. He found that the color of the skin or of the hair had no effect on the degree of the reaction. He observed a variation of 700 per cent in the different individuals between the slightest visible erythema (first degree reaction) and ulceration (a second degree reaction). He found that the curve of pigment followed the waves of erythema as a rule, although there might be more or fewer waves. At times the pigment followed only the third wave of erythema.

From this study it can be seen that the roentgen erythema follows a wave-like course. While he did not mention if there were more, Miescher described three waves of erythema. The fact that he placed the highest degree of reaction at the third wave suggests that there were more waves of erythema to follow.

This work has been confirmed by Pohle, who used a skin-capillary microscope to study the course of the erythema. Reisner and Neeff showed similar curves, using Miescher's method of recording results.

DESCRIPTION OF THE SPECTROPHOTOMETER

In our experiment, an attempt was made to show, by means of the spectrophotometer, the course of the erythema following a single dose of roentgen rays. The spectrophotometer used was the direct reading instrument developed by Keuffel and Esser and referred to as the "K and E color analyzer." The instrument was placed on the market

mainly for industrial applications, such as the grading of oils, estimating the concentration of colored solutions, detecting the nature of pigments in solution, the color of dyes, cloths, and paper, for the standardization of tinted glass and films, and so forth (Figs. 2 and 3). While a complete description of the instrument may be found in the literature, it may not be amiss to review the construction and principles.

A spherical lamp housing of cast aluminum, painted on the inside with zinc oxide paint, contains two 400-watt stereopticon bulbs. This ensemble serves as a source of white light which is constant during the course of the readings. Smooth blocks of magnesium carbonate at the rear of the sphere serve to reflect the light through various transparent media which are maintained in position in a holder placed between the sphere and spectrophotometer proper. If an opaque body, like the skin, is to be studied, the holder is shifted out of the path of the light.

Because of the rather intense heat developed by the incandescent bulbs, the color of living objects would tend to be modified. For this reason, Brunsting and Sheard devised a water-cell appliance which takes the place of the two blocks of magnesium carbonate and their holder. The water cell consists of a thin metal container through which water circulates, to keep it cool. There are two holes in the water cell, corresponding to the apertures in the light sphere, and of the same size. The lower aperture is covered with a thin metal plaque, painted on the inside with magnesium carbonate paint. This serves as a standard since it takes the place of a block of magnesium carbonate. The other hole serves to admit the light to the specimen to be examined. The side of the water cell toward the specimen is covered with felt, so that the cool surface of the metal is separated from the specimen and, hence, cannot affect the color. The disadvantage of the extra centimeter of distance is amply made up by the advantage of keeping the specimen cool.

The two beams of light reflected from the skin and the standard, respectively, enter the spectrophotometer for analysis. The spectrometer is essentially an instrument of the ordinary constant deviation type, except that there is a biprism by which the visual field is divided into two symmetric halves, and an adjustable slit is provided in the observing end of the eyepiece. The desired wave length is obtained by turning a calibrated dial as shown in Figure 3. The amount of light entering the spectrometer may be varied by means of a rotating variable sector (the photometer) which is controlled by the calibrated drumhead shown in Figure 3. The light from the test object goes through the sector unchanged while the light from the standard is reduced in brilliance to that of the test object. The image at the observing slit consists of two semicircular colored fields which have the same hue, this depending on the wave length only. Since the hue of the two fields is the same, the matching of the two fields is independent of the condition of the observer's color vision. Equality of brightness is obtained by rotating the drumhead on the photometer until an exact match is obtained. This reading, taken directly from the drumhead, is recorded as the percentage of light reflected from the specimen at the particular wave length for which the spectrometer is set. Throughout this experiment the entrance and exit slits were kept at a constant width. This was determined by using the light reflected from two magnesium carbonate blocks and adjusting the slits until there was 100 per cent reflection from the two blocks.

In making the readings, the portion of the skin to be examined was placed flush with the water-cooled cell. The actual readings were made by turning the calibrated wheel (Fig. 3) through a distance corresponding

to 10 millimicrons. The percentage of light reflected at each wave length was obtained directly by turning the drumhead (5, in Fig. 3) until an exact match of brilliance was achieved. From the data obtained, a spectrophotometric curve was plotted using the wave lengths as abscissæ and the percentages of reflection as ordinates (Fig. 1). From such a spectrophotometric curve, an experienced observer can determine certain characteristics of the object under consideration by studying the form of the curve in certain spectral regions. Since the spectrophotometric readings measure the spectral distribution of color and so measure the stimulus, they are independent of the condition of the observer's color vision. All observers, therefore, should obtain the same experimental results. Spectrophotometric measurements are independent of the character of the light, provided it is intense enough. This is a great advantage over color matchings by direct vision.

CONVERSION OF SPECTROPHOTOMETRIC DATA INTO TERMS OF COLOR VISION

In order to convert the curves of spectral reflection or transmission into a form to be interpreted directly into the attributes of color, it is necessary to make certain computations based on the theory of three-color mixtures as a form of color specification. This theory is probably the most fundamental of all concepts regarding color (26). It represents the law of three-color mixture and can be represented graphically in terms of red, green, and violet excitation values spread on an equal energy spectrum and referred to average noon sunlight illumination. The principal developments regarding these relations were made by Maxwell, Abney, König, and Dieterici.

The spectrophotometric data, obtained as direct readings from the color analyzer, may be translated into hue, saturation, and brilliance. It is necessary that such readings be combined with a certain energy distribution representative of the particular source of light by which the object is viewed. This can be disregarded in the particular instrument used, as the energy distribution of the two tungsten filament lamps is practically the same as average noon sunlight. The report of the Committee on Colorimetry of the Optical Society of America (31) furnishes the following information:

(A) Multiply each of the ordinates of the transmission or reflection curve by the corresponding ordinates of the energy distribution curve of the source.

(B) Multiply each of the ordinates of the resulting curve by the corresponding ordinates of each of the color excitation functions, as given in Table I ('Excitations'), this being a separate operation for each of the three excitations, yielding three separate curves which represent the respective excitation values for each wave length of the given stimulus.

(C) Determine separately the areas of the three curves thus found. This latter operation can be performed by applying a planimeter to a graph of the resultant curves or—with sufficient accuracy—by finding the sum of representative ordinates of each curve, taken separately at uniform, small intervals such as 10 mμ—throughout the range of the curve in question.

(D) Reduce the three areal values thus obtained to percentage form, so that their determined ratio remains unchanged but their sum becomes equal to 100. The color excitation values can now be expressed by means of two numbers, representing the red and violet excitation percentages, that for the green being obtainable by subtracting the sum of these two values from 100.

The dominant wave length and purity may be determined from Figure 4, by applying the values of the red and violet excitations obtained from an analysis of the spectrophotometric data.

The conversion of spectrophotometric data as described in the foregoing paragraph may be accomplished more rapidly and more

simply by means of a special slide rule adapted to this purpose by Keuffel and Esser. The rule is used as follows: the slide is set at the percentage of light reflected at a given wave length (the reading taken from the calibrated drumhead, 5, of the photometer in Figure 3). The line is then set at the given wave length marked on the rule for red, green, violet, and relative luminosity values and the proportionate values read off the slide and tabulated. This is repeated for the 28 readings from 430 to 700 millimicrons. The resulting columns of figures are added. The totals for the red, green, and violet values are then reduced to percentage form so that their sum equals 100. The total for the relative luminosity values (in units) is put in percentage form; 10.4104 units are taken as 100 per cent, since this number of units represents the total relative light (as average noon sunlight) reflected from a pure white surface.

THE COLOR OF THE SKIN FOLLOWING A SINGLE EXPOSURE TO ROENTGEN RAYS AS ANALYZED BY THE SPECTROPHOTOMETER

This experiment was undertaken for the purpose of determining, as accurately as possible, the course of the roentgen erythema. The subjects used in this experiment were selected from among the Fellows and technicians. An area 8 × 8 cm. on the lateral aspect of the left leg was selected for irradiation. The area was large enough to get a nominal amount of back-scattering. So that all the areas might be the same size, a hole 8 × 8 cm. was cut in a piece of lead rubber. The rubber was then faced with 1 mm. lead sheet and the whole was bound with adhesive tape. Homologous areas on the calf of the leg were selected because of convenience and also because they presented, for the size of the field involved, a fairly flat and uniform surface.

The factors of exposure were as follows: the potential across the tube was 135 K.V. peak value as measured by standard spheres. The current, which was 5 ma., was measured by two instruments. The focal skin distance was 40 centimeters. A Coolidge universal broad focus tube, of the type employed in treatment by moderate voltage, was used. The exposure time was 21 minutes. The output of radiation at this setting was 25 r per minute. The total dose to the areas was 525 r, measured in air. The area received no further exposure during the course of the experiment. The dose used has been found clinically to cause threshold erythema; that is, slight redness in 80 per cent of cases. The quality of the rays was as follows: the effective wave length by Duane's formula for 2 mm. aluminium was 0.31 Ångström unit. The half value layer in aluminium was 6.1 millimeters.

Spectrophotometric readings were taken immediately before irradiation and every day, as far as possible, after irradiation. In one instance (subject H. R. C.) the first reading was made three hours after irradiation.

No particular effort was made to protect the irradiated skin. It was desirable that the conditions following irradiation should be as nearly as possible the same as after therapeutic irradiation. The work was done in November and December so that the factor of sunburn did not enter into the experiment.

The adjustment of the spectrophotometer was not changed during the readings, which took place during from fifty to fifty-five days. The spectrometer was checked twice with a sodium flame to determine the correctness of the wave length scale setting.

The relative luminosity values (or brilliance) were used as a determinant of the pigment content (tanning) of the skin. As Brunsting and Sheard have shown, an increase in pigment content in the skin affects only one attribute of the color, namely, rela-

TABLE I.—SPECTRAL COLORS IN TERMS OF ELEMENTARY EXCITATIONS*

Wave length, millimicrons	Excitations			Wave length, millimicrons	Excitations		
	Red	Green	Violet		Red	Green	Violet
400			253	550	424	612	18
410			433	560	466	578	11
420			614	570	505	517	7
430			915	580	520	415	4
440		7	1,019	590	535	296	
450		16	950	600	510	196	
460		38	842	610	462	113	
470		81	842	620	375	59	
480	14	122	473	630	285	29	
490	41	169	220	640	195	10	
500	83	260	123	650	118	3	
510	151	391	87	660	68		
520	233	510	61	670	40		
530	307	572	43	680	22		
540	373	603	29	690 to 750	27		

*These values are for an equal energy spectrum. The relative magnitudes of the three elementary excitations have been chosen so that the curves for average noon sunlight have equal areas; that is, if the percentage values are plotted on a trilinear diagram, sunlight falls in the center. The absolute excitation values are based on a convenient arbitrary unit.

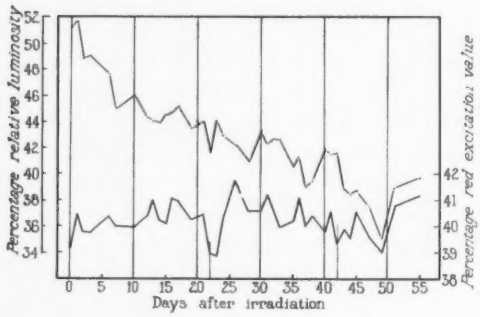
tive luminosity. The content of pigment of the skin and the relative luminosity bear a reciprocal relation to each other; when the pigment content is high, the relative luminosity is low and *vice versa*. The data of the red excitation values were used to determine the degree of erythema. One could just as well use the reciprocal of the violet excitation values. Or again, the purity data could be used, since the curves for the values of the red excitation and purity (Fig. 11) are almost identical. The red excitation values adapt themselves to the idea of erythema more logically than the other values.

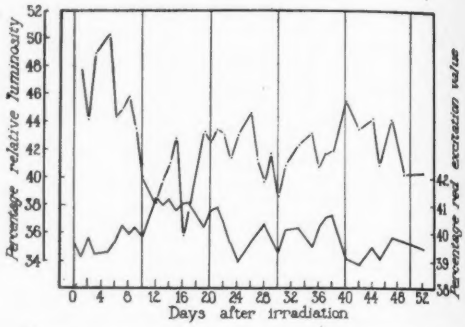
RESULTS

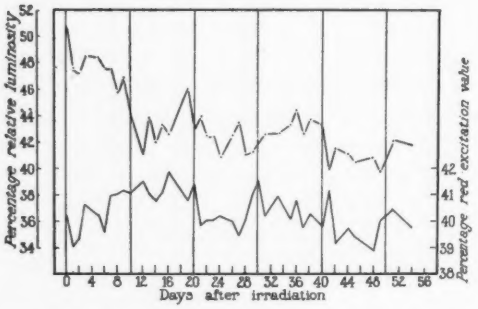
The subject, M. H. R. (Table II), male, 25, of pronounced brunette type and considerably tanned on the exposed areas of the skin, although the skin protected by clothing was fair. The erythema, as evidenced by the red excitation values plotted in Figure 5, showed a wave which reached its highest value on the first day following irradiation and was completed on the third day. From then on there was a variable wave which reached its highest value on the sixteenth day, gradually decreasing until the twenty-first day, at which time there was a decided drop. Another wave started immediately, reaching its maximum on the twenty-sixth day. This point was the highest value of the erythema obtained in the entire course. From then until the forty-first day, there were rather marked undulations. On the forty-second day, the redness dropped to a level which existed before irradiation. Another wave rose to its peak on the forty-fifth day, dropping to its lowest point in that portion of the curve on the forty-ninth day. It was apparent also that another wave had formed and risen to a high level on the fifty-fifth day, when the experiment was ended. The relative luminosity or brilliance (Fig. 5) showed a fairly steady rate of decline to the forty-ninth day, followed by a rise to the fifty-fifth day. This corresponded to the evident increasing pigmentation which was present months after irradiation.

The subject, E. J. J. (Table III, Fig. 6), male, 36, of light brunette type. There was moderate tanning of the exposed por-

tions of the body. The erythema (red excitation values), which on the first day was less than that of the normal skin before irradiation, rose to a high value on the second day. Another wave of erythema formed, reaching its highest value on the twelfth day, when it remained fairly constant until the twenty-first day. From there it dropped, to reach its lowest value on the twenty-fourth day. Three short waves followed, the highest point being on the thirty-eighth day, followed by a decrease in value to the forty-second day. Two other small waves were evident before the experiment ended. The relative luminosity (brilliance) values, as reciprocal evidence of tanning, showed a marked drop on the second day with a sharp rise to the fifth day, and a more steady fall to the sixteenth day. The values then showed a more or less undulating course with some indication of waves between the sixteenth and thirtieth days, and between the thirtieth and fiftieth days.







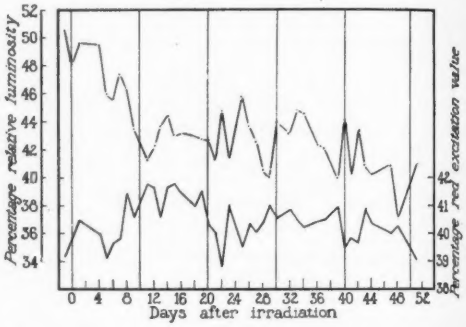


Fig. 5 *(upper left)*. Subject M. H. R., curves of the relative luminosity (upper) and red excitation values (lower).

Fig. 6 *(upper right)*. Subject E. J. J., curves of the relative luminosity (upper) and red excitation values (lower).

Fig. 7 *(lower left)*. Subject D. G. V., curves of the relative luminosity (upper) and red excitation values (lower).

Fig. 8 *(lower right)*. Subject H. R. C., curves of the relative luminosity (upper) and red excitation values (lower).

The subject, D. G. V. (Table IV, Fig. 7), was a woman, aged 25 years, a brunette, with moderate tanning of the exposed surface of the skin. The course of the erythema (red excitation values) decreased immediately after irradiation, being followed by a sharply rising wave which reached its crest on the third day and was completed on the sixth day. A well-formed wave, reaching its highest point on the six-

TABLE II.—SPECTROPHOTOMETRIC DATA FROM THE SUBJECT M. H. R.

Days after irradiation	Red excitation values	Green excitation values	Violet excitation values	Relative luminosity	Dominant wave length	Purity	Observed color of the skin*
	39.34	35.90	24.76	51.32	581	33	
1	40.43	35.72	23.85	51.82	584	36	R
2	39.81	35.69	24.50	48.86	583	33	R
3	39.77	35.84	24.39	49.09	582	34	
6	40.35	36.65	23.00	47.79	581	40	R T
7	40.00	35.92	24.08	44.99	583	35	R
10	39.98	36.83	23.19	46.02	580	38	R
12	40.39	36.73	22.92	44.29	580	40	
13	40.96	36.63	22.44	44.03	582	41	
14	40.25	37.20	22.54	43.94	579	41	R
15	40.09	36.57	23.34	44.50	580	38	
16	41.06	36.48	22.45	44.68	582	41	R
17	40.91	37.15	21.94	45.10	581	42	T
19	40.28	36.37	23.35	43.40	581	39	T
21	40.48	36.69	22.83	44.09	581	40	
22	38.95	36.09	24.95	41.54	585	32	T
23	38.86	36.49	24.65	44.19	579	33	T
24	40.12	36.36	23.52	42.91	580	35	T R
26	41.76	37.00	21.24	42.24	581	43	R
28	40.58	36.20	23.22	40.98	582	38	T
30	40.58	36.63	22.79	43.29	580	40	T
31	41.32	36.82	21.86	42.28	581	43	T
33	39.93	36.58	23.48	42.61	580	37	T
35	40.18	36.42	23.40	40.57	582	37	T
36	41.02	36.89	22.08	41.30	581	42	T R
37	40.03	36.15	23.82	38.89	581	36	T
38	40.43	36.00	23.57	39.40	583	37	T
40	39.75	37.00	23.25	41.94	580	38	T
41	40.53	35.32	23.15	41.51	582	39	T
42	39.32	36.84	23.83	41.58	579	36	T
43	39.90	35.92	24.18	38.87	582	35	T
44	39.55	35.29	25.16	38.46	584	31	T
45	40.56	36.75	22.69	38.78	583	40	T
47	39.61	35.09	25.30	37.49	585	30	T
49	39.04	35.05	25.90	34.91	584	28	T
51	40.78	36.33	22.89	38.98	582	40	T
55	41.14	36.84	22.01	39.70	581	42	R T

*R = redness; T = tanning

teenth day, followed the first wave. The low point of this wave occurred on the twenty-first day. A small wave developed, with its low point on the twenty-seventh day. This was followed by a sharp rise on the thirtieth day, an irregular curve with the low point on the forty-second day, and a still lower point on the forty-eighth day. There was evidence of a small wave preceding the end of the experiment on the forty-fourth day. The relative luminosity showed a gradual decrease to the twelfth day, followed by a more or less level course with, however, a downward tendency. There were two waves present; one between the twelfth and twenty-fourth days and the other between the twenty-fourth and forty-ninth days.

The subject, H. R. C. (Table V, Fig. 8), was a woman, aged 25 years, definitely a blonde; there was little tanning of the exposed areas of skin. The first reading was

TABLE III.—SPECTROPHOTOMETRIC DATA FROM THE SUBJECT E. J. J.

Days after irradiation	Red excitation values	Green excitation values	Violet excitation values	Relative luminosity	Dominant wave length	Purity	Observed color of the skin
	39.60	36.20	24.20	47.77	581	33	
1	39.10	36.20	24.70	47.62	581	32	
2	39.80	35.85	24.34	44.08	583	35	
3	39.20	36.37	24.43	48.83	580	33	
5	39.30	36.26	24.44	50.26	581	32	
6	39.69	36.70	23.61	44.28	580	36	R ?
7	40.26	36.52	23.21	44.85	581	38	
8	39.94	35.80	24.26	45.83	582	34	
9	40.17	36.17	23.65	43.39	582	37	
10	39.80	36.30	23.91	39.95	580	36	
12	41.23	36.71	22.06	38.16	582	42	
13	40.94	35.90	23.16	39.70	584	38	
14	41.18	36.97	21.85	40.66	580	42	
15	40.78	36.84	22.38	42.86	580	41	
16	41.00	35.67	23.33	35.75	584	38	R ?
17	41.09	36.20	22.70	39.83	583	40	T
19	40.17	36.80	23.03	43.33	581	39	
20	40.77	37.48	21.74	42.42	580	42	T
21	40.89	36.98	22.13	43.43	581	42	
22	40.31	36.51	23.14	43.07	581	38	T
23	39.58	35.86	24.56	41.12	581	34	T
24	38.93	35.66	25.41	42.96	582	30	
26	39.62	36.90	23.48	44.83	580	36	R
27	39.93	36.45	23.62	41.10	581	37	
28	40.25	36.20	23.55	39.44	582	37	
29	39.77	36.70	23.53	41.89	580	37	T
30	39.22	35.59	25.19	38.25	584	31	
31	40.09	36.06	23.85	40.81	582	36	R T
33	40.13	36.35	23.52	42.32	582	37	R T
35	39.44	36.05	24.51	43.12	581	34	R ?
36	40.16	36.16	23.68	40.59	583	36	T
37	40.46	36.05	23.49	41.82	583	37	
38	40.57	37.15	22.28	41.63	579	42	
40	39.02	36.92	24.06	45.75	579	35	R
42	38.80	35.91	25.30	43.43	585	31	T?
44	39.42	36.23	24.35	44.17	581	34	T
45	39.08	36.28	24.64	40.73	580	33	T
47	39.84	37.00	23.15	44.24	579	38	
49	39.63	36.09	24.28	40.15	582	34	T
52	39.42	35.71	24.87	40.28	581	32	T

made three hours after irradiation. Visible redness was present. The red excitation values showed the beginning of a wave of erythema which reached its highest value on the day following irradiation, being completed on the fifth day. A sharply outlined wave of erythema, with a somewhat irregular crest, followed. The highest point occurred on the fifteenth day. The lowest point of this second curve occurred on the twenty-second day. This was followed immediately by an irregular third wave, with high points on the twenty-third, twenty-ninth, and thirty-ninth days. The low point occurred on the fortieth day, followed by a wave lasting eleven days, with the lowest point on the fifty-first day. This third wave apparently extended from the twenty-second day to the fifty-first day.

The relative luminosity values (brilliance) showed a steady decline until the eleventh day, followed by an irregular course with a

TABLE IV.—SPECTROPHOTOMETRIC DATA FROM THE SUBJECT D. G. V.

Days after irradiation	Red excitation values	Green excitation values	Violet excitation values	Relative luminosity	Dominant wave length	Purity	Observed color of the skin
	40.20	36.09	23.71	50.43	581	35	
1	39.02	35.82	25.16	47.56	581	32	R
2	39.35	35.58	25.07	47.14	582	32	R
3	40.64	36.23	23.13	48.58	582	37	R
5	40.22	36.00	23.78	48.33	583	35	R
6	39.58	35.92	24.50	47.42	583	33	R
7	40.97	36.20	22.83	47.47	582	38	
8	41.20	36.14	22.66	45.61	583	40	
9	41.12	36.10	22.78	46.97	584	39	R
10	41.06	36.73	22.21	44.16	581	42	R
12	41.50	36.33	22.17	40.93	583	41	R
13	41.06	36.36	22.58	43.96	582	40	R
14	40.79	35.98	23.23	41.89	584	38	R
15	41.08	36.24	22.68	43.39	583	40	R T?
16	41.83	36.23	21.94	42.47	584	42	R
19	40.79	36.37	22.84	46.15	582	40	R
20	41.36	36.93	21.71	42.91	580	42	
21	39.83	35.98	24.18	43.97	582	34	
22	40.03	36.39	23.58	42.36	580	37	T
23	40.03	36.11	23.86	42.43	583	36	T
24	40.17	36.07	23.76	40.81	582	35	R
26	39.96	36.06	23.98	42.44	583	35	R
27	39.42	35.65	24.93	45.49	582	32	R
28	40.03	36.37	23.59	41.04	581	36	R
29	40.98	36.40	22.62	41.23	583	41	T R
30	41.52	36.21	22.27	38.46	583	42	T
31	40.14	36.25	23.61	42.60	581	37	R T
33	40.94	36.84	22.22	42.65	581	42	T R
35	40.06	35.59	24.35	43.24	584	34	T R
36	40.78	36.90	22.32	44.43	580	41	R T
37	39.71	36.64	23.64	42.53	580	36	R T
38	40.34	36.85	22.81	43.68	580	40	R T
40	39.77	36.00	24.23	43.34	582	34	T R
41	41.14	35.83	23.03	39.79	584	38	T R
42	39.14	35.74	25.12	41.66	582	32	T
44	39.73	35.64	24.63	41.08	583	33	T
45	39.46	36.47	24.07	40.45	580	35	R T
48	38.85	35.32	25.82	40.80	580	30	T R
49	39.94	35.66	24.40	39.65	584	34	T R
51	40.46	36.34	23.20	42.08	581	38	T R
54	39.72	35.73	24.55	41.71	583	33	

downward tendency. Two fairly definite waves could be made out, which occurred between the eleventh and twenty-first days and between the twenty-ninth and thirty-ninth days.

The subject, F. H. D. (Table VI, Fig. 9), male, 30, of brunette type, with unexposed portions of skin somewhat darker than that of the other subjects. The first wave of erythema had a crest on the second day and its low point on the fifth day following irradiation. The second wave was very irregular, having crests on the seventh, ninth, thirteenth, and nineteenth days. The lowest point of this wave was on the twenty-second day. The third wave, which was also very irregular, reached its crest on the thirty-sixth day. Its lowest point was on the forty-seventh day, followed by a rising erythema to the fifty-second day, at which

TABLE V.—SPECTROPHOTOMETRIC DATA FROM SUBJECT H. R. C.

Days after irradiation	Red excitation values	Green excitation values	Violet excitation values	Relative luminosity	Dominant wave length	Purity	Observed color of the skin
0	39.18	36.11	24.71	50.48	581	32	
0	39.93	36.17	23.90	48.02	580	36	R
1	40.47	35.92	23.60	49.61	582	36	R
4	39.98	35.99	24.03	49.59	583	35	
5	39.10	35.68	25.22	45.90	581	31	R
6	39.62	35.91	24.46	45.47	581	33	R T?
7	39.75	35.83	24.42	47.55	582	34	R
8	41.38	36.36	22.26	46.29	582	41	R
9	40.51	36.29	23.20	43.65	582	39	
11	41.79	36.04	22.17	41.26	584	41	R
12	41.60	36.56	21.84	42.20	582	42	T R?
13	40.52	36.27	23.21	43.70	582	38	
14	41.63	36.91	21.46	44.51	582	43	R
15	41.78	36.76	21.46	42.97	582	44	R
16	41.45	36.64	21.90	43.14	582	42	T
18	40.94	36.93	22.13	42.95	580	42	R T
19	41.51	36.98	21.51	42.78	581	43	
20	40.30	36.64	23.06	42.78	580	39	R
21	40.02	36.50	23.48	41.16	580	37	
22	38.79	36.52	24.69	45.00	579	34	T R?
23	41.00	37.21	21.78	41.13	580	43	T R?
25	39.48	36.55	23.97	45.81	580	35	R
26	40.35	36.38	23.27	43.48	581	38	R T?
27	40.02	36.28	23.70	42.51	581	36	R T
28	40.40	36.35	23.25	40.43	581	37	R T
29	40.97	36.36	22.67	39.95	582	40	T R
30	40.50	36.93	22.57	43.97	580	41	R T
32	40.86	37.21	21.93	43.12	580	42	T
33	40.47	36.41	23.12	44.71	582	37	R T
34	40.20	35.96	23.84	44.60	582	36	R
36	40.38	36.23	23.39	42.21	581	38	
37	40.42	36.74	22.84	42.06	580	40	R
39	40.89	36.60	22.51	39.82	581	41	T
40	39.42	36.05	24.53	44.20	581	33	T
41	39.81	36.19	24.00	40.07	581	35	T
42	39.62	35.50	24.88	43.20	580	32	R T
43	40.79	36.60	22.61	40.74	581	40	T
44	40.34	35.95	23.71	40.18	582	35	
47	39.96	36.08	23.96	40.95	582	35	
48	40.21	34.85	24.94	36.87	585	32	T R?
51	38.98	35.71	25.31	40.87	583	31	R

time the experiment ceased. The relative luminosity values showed a slightly irregular fall to the thirteenth day, followed by an irregular course with a tendency upward. No wave forms were apparent.

The subject, S. A. M. (Table VII, Fig. 10), male, aged 30, of marked brunette type, with considerable tanning of the exposed areas of skin. The erythema showed the first crest of a wave on the sixth day and its low point on the eighth day. Then followed a wave with its crest on the tenth day and its minimal value on the sixteenth day, followed by another wave with its crest on the twentieth day and its low point on the twenty-first day. The second wave apparently included the last two waves and extended from the eighth to the twenty-first days. Between the twenty-first and the forty-second days the usual third wave

TABLE VI.—SPECTROPHOTOMETRIC DATA FROM SUBJECT F. H. D.

Days after irradiation	Red excitation values	Green excitation values	Violet excitation values	Relative luminosity	Dominant wave length	Purity	Observed color of the skin
0	38.51	36.00	25.49	48.30	585	30	
1	38.94	36.12	24.93	49.02	580	32	
2	39.56	36.14	24.30	48.53	580	34	
3	39.31	36.06	24.63	43.32	582	33	T
5	38.86	35.68	25.54	45.26	583	30	T
6	38.96	36.19	24.85	46.09	580	32	
7	40.27	36.51	23.22	45.72	581	39	
8	39.10	35.77	25.12	44.80	583	31	R
9	40.60	36.27	23.13	45.03	583	37	T R
10	38.53	36.70	24.77	48.14	579	33	
12	40.19	36.61	23.20	46.22	581	38	R?
13	40.75	35.18	24.07	41.14	585	35	
14	40.74	36.78	22.48	43.86	582	40	T?
15	39.90	36.89	23.21	47.09	580	38	R
16	39.32	35.68	25.00	45.41	583	32	R
17	39.73	35.02	25.24	43.66	585	30	
19	40.69	36.41	22.86	40.96	581	40	R
20	40.04	36.24	23.72	45.04	581	37	R
21	39.17	36.14	24.69	42.97	580	32	
22	38.70	36.03	25.27	42.61	580	30	R
26	39.73	36.27	24.00	45.90	580	35	R
27	39.32	36.01	24.67	45.47	581	32	R
28	39.53	36.18	24.29	44.19	580	34	T
29	40.06	36.67	23.27	43.93	580	38	T R
30	39.01	36.47	24.52	44.69	580	34	T R
31	39.45	36.13	24.42	45.05	580	33	
33	39.53	36.29	24.18	47.33	581	35	T
35	40.25	36.82	22.93	49.33	580	38	
36	40.30	36.41	23.29	45.99	580	38	T
37	38.71	36.25	25.04	49.09	580	32	T
38	39.15	36.62	24.23	46.10	580	34	T
40	39.47	35.88	24.65	49.85	581	33	T
41	38.87	36.26	24.87	51.24	580	33	
42	38.33	36.16	25.51	46.14	580	30	T
43	38.66	35.37	25.97	43.66	582	28	T
44	39.46	35.61	24.93	46.25	583	32	
47	38.27	35.91	25.82	44.29	580	29	T
49	38.44	35.74	25.82	49.62	581	29	
52	40.03	36.47	23.50	45.76	580	37	T

occurred, made up of three smaller waves. The crests of these three waves were on the twenty-eighth, thirty-fifth, and forty-first days, respectively. After the forty-second day, an irregular wave with low maximal values was evident, showing a rise to the fifty-fourth day, at which time the readings ended. The relative luminosity showed a decrease to the tenth day, followed by an irregular course with a tendency downward. Three wave forms were more or less evident: the first between the tenth and twentieth days; the second between the twentieth and twenty-ninth days, and the third between the twenty-ninth and forty-fifth days.

The green excitation values of all these subjects (Tables II to VII) remained practically at a constant level. There was only a slight increase when the red excitation values were highest. The violet excitation values showed an almost exact inverse relationship to the red excitation values. The purity (percentage value of saturation) showed the same variations as the red exci-

TABLE VII.—SPECTROPHOTOMETRIC DATA FROM SUBJECT S. A. M.

Days after irradiation	Red excitation values	Green excitation values	Violet excitation values	Relative luminosity	Dominant wave length	Purity	Observed color of the skin
0	38.69	35.66	25.65	48.40	583	27	
1	39.12	35.78	25.19	49.89	583	30	
2	39.35	35.87	24.78	43.52	582	32	
3	39.80	35.85	24.35	44.07	583	34	
5	39.94	35.44	24.62	46.29	585	32	R
6	40.17	36.71	23.12	45.72	582	39	T
7	39.97	36.03	24.00	41.84	583	35	
8	39.81	36.29	23.90	44.26	582	35	
9	40.23	35.38	24.39	42.26	584	34	R
10	41.04	36.50	22.46	39.63	582	40	
12	40.68	36.52	22.80	43.81	582	40	
13	40.14	36.45	23.41	45.08	581	38	R
14	39.76	36.57	23.67	41.63	580	36	
15	39.44	36.27	24.29	43.19	581	34	R
16	39.46	36.50	24.04	41.79	580	35	T R
17	40.16	35.77	24.07	42.06	583	35	
19	41.06	36.30	22.64	39.87	583	40	R
20	41.07	36.67	22.26	38.91	581	41	T
21	39.04	35.33	25.63	40.25	584	30	
22	39.95	36.00	24.05	41.51	582	35	T
23	40.15	35.54	24.31	40.10	584	34	T
24	40.16	36.35	23.49	42.23	581	37	R T
26	40.24	36.44	23.32	42.17	581	38	R
27	40.51	36.64	22.85	43.13	581	39	T
28	41.15	36.43	22.42	38.97	582	40	R T
29	39.34	36.22	24.44	40.05	581	32	T
31	40.26	36.35	23.39	41.24	581	38	
33	40.40	36.59	23.01	41.67	581	39	T
35	41.05	36.50	22.45	40.11	582	39	R
36	39.78	36.01	24.21	42.30	582	35	R T
37	39.32	36.83	23.85	42.85	580	37	T
38	39.28	35.95	24.77	40.39	582	33	T
40	39.78	35.74	24.48	41.53	582	34	T
41	40.52	35.42	24.06	38.77	585	35	T R
42	39.06	36.36	24.50	41.95	580	34	T
43	39.40	35.35	25.25	40.17	585	31	T
44	39.05	36.29	24.66	42.56	580	32	T
45	39.42	35.61	24.97	36.38	582	32	T
49	39.82	35.85	23.33	39.32	581	34	T
51	39.27	35.88	24.85	39.60	581	32	T
54	40.03	35.04	24.93	37.82	585	31	T

tation values. The dominant wave length (hue) varied between 579 and 585 millimicrons. Most of the determinations were between 581 and 583 millimicrons. The slight variations bore no relationship to the variations in the other values.

Direct visual observation of the color of the skin was made with no intent other than to determine, if possible, when the erythema and tanning were present. No attempt was made to record accurately any quantitative results. The recorded visual results corresponded only roughly to the spectrophotometric data of the erythema or redness of the skin, corresponding more accurately, however, to the tanning of the skin. That is, when the relative luminosity was low, the skin appeared to be tanned.

The composite of the data presented in the preceding tables and figures is given in

TABLE VIII.—MEANS OF THE SPECTROPHOTOMETRIC DATA CONTAINED IN TABLES II, III, IV, V, VI, AND VII

Days after irradiation	Number of subjects in mean	Red excitation values	Green excitation values	Violet excitation values	Relative luminosity	Dominant wave length	Purity
0	6	39.37	36.00	24.61	49.04	581.8	32.3
1	6	39.51	35.92	24.57	49.25	581.8	33.0
2	5	39.57	35.82	24.59	46.42	582.0	33.2
3	5	39.74	36.07	24.18	46.77	581.8	34.2
5	5	39.48	35.81	24.72	45.40	582.6	32.0
6	6	39.72	36.34	23.92	46.12	581.1	35.5
7	6	40.20	36.16	23.62	45.40	582.0	36.5
8	5	40.25	36.07	23.64	45.35	582.4	36.2
9	5	40.52	36.04	23.43	44.26	583.0	37.2
10	5	40.08	36.61	23.30	43.58	580.4	37.8
12	6	40.93	36.57	22.49	42.60	581.6	40.5
13	6	40.72	36.13	23.17	42.93	582.6	38.3
14	6	40.72	36.73	22.54	42.74	581.1	40.0
15	6	40.51	36.59	22.89	44.00	581.0	39.1
16	6	40.68	36.20	23.09	42.20	582.5	38.3
17	4	40.47	36.03	23.48	42.66	583.0	36.7
19	6	40.75	36.53	22.70	42.74	581.5	40.1
20	5	40.70	36.79	22.49	42.41	580.4	40.2
21	6	40.64	36.27	23.82	42.64	581.3	35.8
22	6	39.45	36.25	24.28	42.68	581.1	34.3
23	5	39.92	36.24	23.63	41.79	581.4	36.0
24	4	39.84	36.11	24.04	42.22	581.2	34.2
26	6	40.27	36.50	23.21	43.51	581.0	37.5
27	5	39.84	36.20	23.95	43.54	581.2	35.2
28	6	40.32	36.28	23.38	40.84	581.3	37.0
29	5	40.13	36.47	23.30	41.41	581.2	37.6
30	5	40.16	36.36	23.46	41.73	581.4	37.6
31	5	40.25	36.32	23.42	42.39	581.0	37.4
33	6	40.23	36.51	23.25	43.54	581.6	37.8
35	5	40.19	36.27	23.52	43.27	581.0	36.4
36	6	40.40	36.17	23.16	42.80	581.1	36.3
37	6	39.78	36.44	23.78	42.87	580.6	36.3
38	5	39.95	36.51	23.53	42.24	580.8	37.2
40	6	39.53	36.26	24.19	44.43	580.8	34.5
41	5	40.17	36.00	23.82	40.27	582.4	36.0
42	6	39.04	36.08	24.85	42.99	581.0	32.5
43	4	39.68	35.81	24.50	40.86	582.5	33.5
44	6	39.59	35.83	24.40	42.11	582.1	32.8
45	4	39.63	36.27	24.09	39.02	581.2	35.0
47	4	39.42	36.02	24.55	41.74	581.5	33.0
49	5	39.37	35.67	24.94	40.73	582.4	31.8
51	4	39.87	36.08	24.06	40.38	581.7	35.2

Table VIII and Figure 11, representing the average values of six cases only. It is to be interpreted in this light. The relative luminosity decreased steadily to about the fortieth day, followed by a slightly less rapid decrease to the fifty-first day. The red excitation values showed a wave having its crest on the third day and its low point on the fifth day. This was followed by a second wave, reaching its highest value on the twelfth day. Its course was fairly level until the twenty-first day, from which point it dropped to a low level on the twenty-second day. A third wave began imme-

diately thereafter, occurring between the twenty-second and forty-second days. There was little evidence of activity after the forty-second day, as shown by the curve of percentage red excitation (Fig. 11). The currence in the six cases studied are shown in Table IX.

The first wave of erythema reached its highest value in an average of 2.5 days, with its succeeding low value at six days,

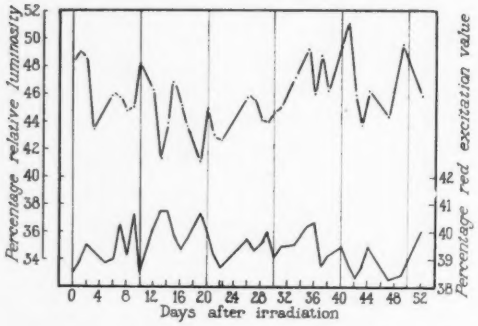


Fig. 9. Subject F. H. D., curves of the relative luminosity (upper) and red excitation values (lower).

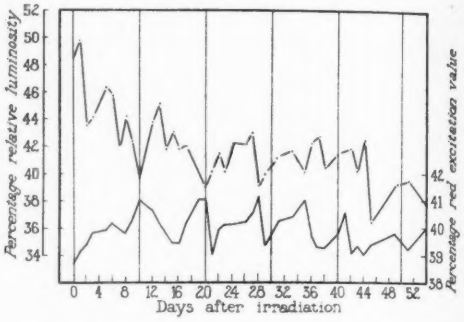


Fig. 10. Subject S. A. M., curves of the relative luminosity (upper) and red excitation values (lower).

third wave was evidently lower in intensity than the second. The green excitation values maintained an almost level course. There was, however, a slight increase in this value when the red excitation values were the highest. The violet excitation values evidenced a reciprocal relationship to the red excitation values. The purity (percentage saturation) values showed, in a more pronounced fashion, the same variations as the red excitation values. The dominant wave length (hue) varied between 580.4 and 583 millimicrons, the course tending to remain constant.

COMMENT

In general, the course of the values of color excitation was cyclic. The rhythm was similar in certain particulars in the different subjects. Definite cycles of erythema and, at times, of tanning were present, as well as rather definitely timed maximums and minimums in the course of the erythema of all the subjects. The average high and low points and the average chronologic occurrence in the six cases studied are shown in Table IX.

on the average. This corresponded exactly to Miescher's first wave, for Miescher found that the maximal point of the first wave occurred, on the average, in two days.

The second wave reached its highest value between the thirteenth and the twentieth days, with an average of 15.6 days. Its low value occurred between the twenty-first and twenty-fourth days, or, on an average, in 22.1 days. This corresponded definitely to Miescher's second wave.

The third wave reached its maximal value between the twenty-eighth and thirty-eighth days, or, on the average, in thirty-two days. Its minimal value occurred between forty-two and fifty-one days, or in 46.5 days, on the average. Therefore, the third wave, as we determined it, extended from the twenty-second day to the forty-sixth day. Miescher described the third wave as occurring between the thirty-fourth and fifty-first days, stating also that this third wave was the most intense of the rhythmic course. In our investigations, the third wave, with one exception (subject N. H. R.), was less pro-

TABLE IX.—AVERAGE HIGH AND LOW POINTS OF THE DIFFERENT WAVES AND MEAN TIME RELATIONS

Subject	First wave				Second wave				Third wave			
	High	Day	Low	Day	High	Day	Low	Day	High	Day	Low	Day
M. H. R.	40.43	1	39.77	3	41.06	16	38.86	23	41.32	31	39.04	49
E. J. J.	39.80	2	39.20	3	41.18	14	38.93	24	40.57	38	38.80	42
D. G. V.	40.64	3	39.58	6	41.83	16	39.83	21	41.52	30	38.85	48
H. R. C.	40.47	1	39.10	5	41.78	15	38.79	22	40.97	29	38.98	51
F. H. D.	39.56	2	38.86	5	40.75	13	38.70	22	40.30	36	38.27	47
S. A. M.	40.17	6	39.81	8	41.07	20	39.04	21	41.15	28	39.06	42
Means:	40.17	2.5	39.38	6.0	41.32	15.6	39.02	22.1	40.97	32.0	38.86	46.5

nounced than the second wave, as is evident from the mean values given in Figure 11. There was also evidence, both from visual and spectrophotometric observations, that the erythemic reaction continued after the occurrence of the third wave.

The apparent, but unimportant, variation in the time of occurrence and duration of the third wave in our investigations and of Miescher's results may be due to the fact that pigment obscures the erythema in visual observation so that accurate readings are impossible. In the spectrophotometric determinations, however, pigmentation affects only the relative luminosity, not the chromic values.

There were, however, considerable differences in the courses of the erythema produced in the various persons examined by us. The greatest differences are exhibited by the subjects S. A. M. and F. H. D., for the rhythm in these cases is very dissimilar from the others. This supports the contention of Leddy and Weatherwax, and others, that marked individual variations follow the administration of a uniform dose of roentgen rays.

The values of the relative luminosity (brilliance) were taken as indicators of the content of pigment in the skin. In general, the courses of these values showed rhythm. After the preliminary decrease and immediate increase in the values of the relative luminosity occurring during the first few days, there was a gradual decrease at a rate which was fairly constant until a time varying between the eleventh day and the fifteenth day was reached; hence the content of pigment underwent rapid variations during the few days immediately after irradiation. Subsequent to these initial variations, there was an increase in the content of pigment, which progressed at a fairly steady rate for from eleven to fifteen days. After this period, the content of pigment in one case (subject F. H. D.) decreased; it remained at about the same level with cyclic variations in three cases (subjects E. J. J., D. G. V., and H. R. C.), and decreased at a more or less constant rate in two cases (subjects M. H. R. and S. A. M.). There were, therefore, marked variations in the course and amount of pigmentation in the skins of subjects after roentgen irradiation. However, it was quite evident that the pigmentary changes, or the changes in the processes involved in the development of pigment, were independent of the erythemic changes in the skin.

The hue (dominant wave length) remained practically constant, ranging from 579 to 585 millimicrons. The purity (saturation) followed the course of the erythema as indicated by the spectrophotometric determinations of the values of red excitation. These experimental observations rela-

tive to hue, color excitation, and saturation indicate that the quality of the blood remains constant, whereas the increase in redness (erythema) is due chiefly, if not wholly, to an increase in the quantity of

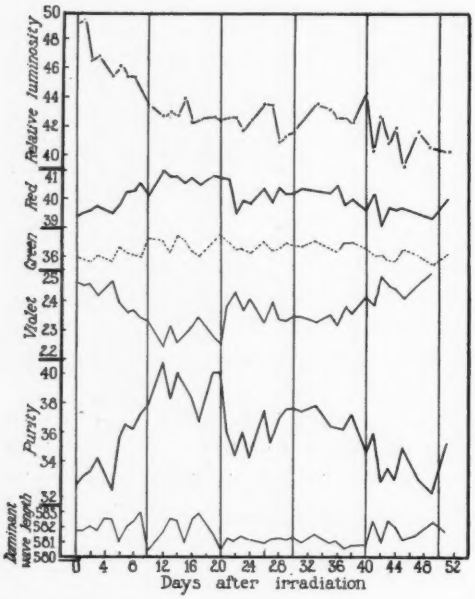


Fig. 11. Curves showing the average values of the relative luminosity, color excitation (red, green, and violet), purity, and dominant wave length.

blood in the peripheral vessels. As Brunsting and Sheard showed, any change in the quality of the blood dependent on the content of oxygen causes a shift in hue toward the red end of the spectrum in hyperemia and toward the blue end of the spectrum in congestion. Hence it may be concluded that the increased redness (erythema) following irradiation is due to the more complete opening of the capillaries and to a great number of open capillaries in the skin, thereby allowing a greater quantity of normal blood to be present. This conclusion is supported by the investigations of the others who have studied the capillaries of the skin.

Although we know little regarding the nature of the physical and chemical factors which produce the changes in function of the capillaries and the pigmentary processes, we may conclude that the same physical agent, that is, roentgen rays, causes both of them. It is certain that the erythema of the skin followed a rhythmic course after roentgen irradiation. Hence it is not logical to assume that the changes in the function of the capillaries are due to a single dose of roentgen rays acting for a short time, the effect of which deteriorates at a fairly constant rate. If such were the case, the relationship between erythema and the time in days after the application of a single dose of roentgen rays would be a straight line on semilogarithmic paper. The values of the relative luminosity, when plotted semilogarithmically, show some semblance to straight lines over a period of from eleven to fifteen days, after which marked irregularity exists. There are rapid variations in pigmentary values, thus indicating that pigment is markedly labile.

It is still a moot question if the erythema produced by irradiation is a measure of the biologic effects produced in the tissues by such irradiation. If it can be assumed that erythema is a biologic change resulting from roentgen rays, and if the mechanism of effect in deep tissues differs in no fundamental respect from that in the skin, then it is logical to assume that reactions in the deeper tissues will closely parallel those observed in the skin. Miescher, Reisner and Neeff, and others, have shown by clinical observation that rhythmic variations in erythema occur and that these variations persist for a considerable period. From an accurate analysis of data regarding hue, saturation, and relative luminosity obtained spectrophotometrically, we have shown that the course of the erythema is cyclic. The course of development of pigment is apparently independent of, and dissimilar to, the course of the erythema, although rhythm, or decided maximums and minimums, ap-

pears after about the fifteenth day following irradiation. In some recent investigations by Williams and Sheard regarding the electric differences of potential across frog's skin and the ratio of consumption of oxygen, it is shown that there is rhythm, or cyclic variation, in both electric potentials and consumption of oxygen. Again, therefore, it would seem that a rhythmic, or wave, type of relationship between the physiologic effect of roentgen rays and the time after irradiation expresses the correct time-effect relationship. The periods of increased potential and consumption of oxygen may be considered as periods of increased activity or vitality, whereas the periods of decreased potential and consumption of oxygen may be presumed to indicate lowered vitality, or periods of injury. The fact that the effects of irradiation on the potential differences and rates of consumption of oxygen appear as rhythmic types of reaction may be due in part to the action of the normal metabolic processes of the cells to counteract, or repair, the injury which has been suffered. Oxidative processes which are proceeding at an abnormal rate may instigate reactions which tend to counteract or interrupt the rate of oxidation. After this has been accomplished, the inhibitory agent may cease to exert its influence and the tendency toward an abnormal rate again may make itself evident. So far as we know, there has been no correlation between these cyclic effects on the electric potentials and rates of consumption of oxygen of irradiated skin on the one hand and the cyclic effects on cutaneous erythema and the less marked rhythm in the development of pigment on the other. We are able only to state: (1) There is a fairly constant rate of development of pigment for a period of from eleven to fifteen days after roentgen irradiation, followed by marked irregularity with subsequent evidences of rhythm, and (2) there is a rhythm or cyclic course of erythema, as evidenced by the curves of percentage red excitation, which is associated largely if not wholly with the amount and distribution of blood in the capillaries of the skin.

CONCLUSIONS

1. Spectrophotometry offers an accurate method of recording the changes of color in the skin following irradiation.

2. The course of the erythema is cyclic, or wave-like, persisting over a period of months.

3. Fairly definite points occur chronologically at which the erythema is at a minimum.

4. Changes in the content of pigment of the skin are due to a primary effect of the rays on the pigment, or on the metabolic processes by which pigment is formed.

5. The content of pigment is immediately affected by irradiation.

6. The pigment follows a course independent of the course of the erythema.

7. The hue of the skin following irradiation remains constant.

8. The changes in redness of the skin following roentgen irradiation are due to changes in the saturation of the hue.

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Goldfish under X-ray Show Development of Pigment.—Forty-seven goldfish have been given X-ray tests to shed light on the little-understood subject of the cause of the formation of pigment-carrying cells in man and lower animals. In man, these pigment-carrying cells erupt in the skin, forming unsightly dark blue patches. Sometimes these patches are birthmarks, sometimes acquired later, as the result of injuries or irritations.

Results of the goldfish experiments are reported to the *American Journal of Cancer* by Dr. George Milton Smith, of the Yale University School of Medicine.

In order to X-ray only one side of forty-seven lively fish, Dr. Smith anesthetized his small subjects. After five or six days of carefully regulated X-ray treatment, the exposed side of each fish began to erupt tiny cells carrying dark coloring matter. These made splotches of black under the transparent outer skin of the fish, and formed interlacing patches against the dark red bodies of the fish. After the treatments, the dark patches remained for almost two weeks and then took from eleven days to about a month to disappear, leaving the fish in the same state as before the experiment—except for four subjects that were so acutely affected that they died, apparently from a secondary infection.

Why X-ray exposure causes goldfish to respond by mobilizing these dark, color-carrying cells in the skin is not yet clear, Dr. Smith reports. There is, he suggests, some connection with repair and defense processes. The whole matter is important to physicians because of the possible connection of the formation of these pigment cells, or melanophores, with the development of pigmented tumors.—*Science Service.*

MEDICO-LEGAL DEPARTMENT

THE PRÆCIPE

By I. S. TROSTLER, M.D., F.A.C.R., F.A.C.P., Chicago

The præcipe is an archaic and antequated legal document, the use of which is still current in about half of the States of this country, while in the others it has fortunately passed into obsolescence and disuse.

This document, where still in use, permits the institution or commencing of a lawsuit *without any explanation or elucidation of the cause of the action.* The most reputable citizens of high standing may be named as defendants in these cases and thereby be subjected to all sorts of inference or conjecture. The suit may not be and *often is not* pressed or followed up, and still the defendant has no redress or remedy at law.

The præcipe itself is a simple document, containing the mere statement that John Doe is suing Joseph Roe for a certain sum of money and naming John Doe's attorney. No hint of the cause of the action is necessarily included, and under the law in the States where it is still permitted, the plaintiff is not required to substantiate the righteousness or justice of his claim until he is ready to file a declaration or withdraw the præcipe.

It is during this period—after the filing of the præcipe and before a declaration is filed—that unscrupulous lawyers press claims and arguments for settlement, and intimidate defendants into paying for a withdrawal or settlement, for fear of publicity and scandal.

Originally, the præcipe was a mandatory letter from the King of England, written by his Chamberlain and bearing his Great Seal. It was directed to the sheriff of the county wherein an alleged injury was committed, and required that the sheriff command the accused party to render justice to the complainant or answer to the accusation against him in court. A legal maxim of the time was that no proceedings could be tried before the King's judges without his (the King's) original writ or præcipe. It was deemed unfit that these judges—being substitutes for the King—should take cognizance of anything except such as had been called to their attention by His Majesty. In those early times, when a complaining witness or plaintiff failed to prosecute a suit after filing a præcipe, he was liable to a fine or imprisonment or both, but in these modern and more intellectually advanced times of ours, there is no penalty imposed for this action in such States as still permit the filing of this opprobrious document, which nearly all honorable attorneys decline to use, and which is used only by attorneys of low ethical and moral standards—legal quacks or legal charlatans.

The writer has personal knowledge of numerous instances wherein præcipes were filed, stating that suits were to be brought for large sums of money, but which were withdrawn after more or less extended periods, either with or without the payment of various sums of money.

This is a favorite document and method of legal procedure for attorneys alleging breach of promise, alienation of affection, medical malpractice and other similar actions smacking of blackmail or extortion, particularly in the more densely populated centers. It is still in use in Illinois.

Physicians when served with this document need have little fear, as a general thing, as in nearly every instance it will prove to be *vox et præterea nihil.*

CASES CITED[1]

UNSUCCESSFUL TREATMENT OF TIBIAL FRACTURE WITHOUT ROENTGENOGRAM

De Bruine *vs.* Voskuil *et al.* (Wis.), 169 N.W.R. 288

The Supreme Court of Wisconsin not only reverses a judgment for $1,800 damages obtained by the plaintiff for injuries alleged to have been sustained by reason of negligence on the part of the defendants in the treatment of a fracture of the tibia of the plaintiff's left leg about two inches below the knee, but remands the case with directions to dismiss the plaintiff's complaint on the merits. The Court says that the plaintiff was a woman 49 years old. The accident occurred November 5. The defendants reduced the fracture and placed it in a fracture box in the ordinary way with Buck's extension, attaching a weight of 26 pounds. December 20, defendant Voskuil removed the apparatus, a part of the weight having been taken off a week previously; and he attempted to ascertain whether or not union had taken place, but desisted on account of complaints made by the plaintiff. He advised her to use her leg. He called again, December 27, and then discovered that there was no union of the fragments. He then advised an operation for the purpose of fastening the ends of the bones together. The plaintiff was taken to a hospital in Sheboygan, where another surgeon performed an operation, ten weeks after which the plaintiff returned to her home, with the bone united perfectly, but her left ankle stiff. It was undisputed that prior to the operation there was never any exudate on the ends of the bones.

There was no evidence to show that the bones were not properly placed in apposition to each other, and there was no evidence to show that the weights were not properly attached in the usual and customary way. If an expert could not say that the treatment was improper, on what ground could the jury arrive at that conclusion? The fact being established that there was no union, it was assumed apparently that it must be due to some negligent treatment. The evidence did not sustain that view. The entire case here rested on the testimony of a physician to the effect that he would have treated the fracture in another way. Physicians are not compelled to choose at their peril between two accepted methods of treatment. Statements of experts that they would have treated the fracture in some other way are incompetent.

The trial court correctly instructed the jury that:

"A physician and surgeon is not an insurer or guarantor of a cure. If the treatment in this case was such as physicians or surgeons of ordinary knowledge and skill of the same school of medicine, and practising in the same vicinity, would have exercised under the same or similar circumstances, then the fact that a bad result followed from the treatment, if you find that that was the fact, is not in itself alone sufficient to charge the defendants or either of them with negligence."

The difficulty seemed to be that the trial court entirely ignored the undisputed fact that the failure of the fragments to unite was due to some cause with which the treatment administered by the defendants had nothing whatever to do; that is, the failure of Nature to set up the healing process.

But there was one claim of negligence as to which there was sufficient evidence to sustain the finding of the jury, and that was that defendant Voskuil was negligent in not discovering the fact that the injury had not healed at the time of the removal of the extension apparatus, and in the defendant's further failure to call on the patient for

[1]Reprinted by permission from *The Journal of the American Medical Association.*

seven or eight days thereafter. However, there was no evidence showing that this in any way contributed to or was a factor in producing the injury complained of.

At the time of the plaintiff's injury there was no roentgenographic apparatus at or near the place where she lived, and there was no suitable electrical current available. Neither did it appear from the testimony that, had a roentgenogram been taken during the treatment, it would have shown that no callus was being formed at the point of fracture. Nor was there cited any case holding that it is as a matter of law negligence for an attending physician and surgeon to fail to avail himself of the use of a roentgenographic apparatus in the case of fracture, and on the facts shown here this Court cannot so hold, particularly as it was comparatively easy to determine whether or not the ends of the bones were in apposition. It is clear that under the facts in this case the failure to procure a roentgenogram during the course of treatment did not amount to negligence or unskillful treatment.

ATTENDING PHYSICIAN NOT LIABLE FOR CONSULTANT'S FEE

Zumwalt *vs.* Schwarz (Calif.), 297 P.R. 608

Ordinarily, when a person requests another to perform certain services the law implies a promise on the part of that person to pay the reasonable value of the services performed. This rule does not apply, however, where a person requests a physician to perform professional services for some one to whom the person making the request is under no legal obligation to furnish medical aid. Where no such legal obligation exists, one who calls a physician to attend another is not liable for the services performed in the absence of an express agreement to pay for them. (21 R. C. L. 412, McClenahan *vs.* Keyes, 188 Calif. 574, 206 P. 454.)

An attending physician, therefore, who with the approval of the patient or his family calls in a consulting physician, acts only as the agent of his patient and is not liable for the payment of any part of the consultant's fee. Under the weight of authority, according to the District Court of Appeal, First District, Division 1, California, the financial condition of a patient may be considered by a jury as affecting the reasonableness of a physician's charges. Even in those jurisdictions holding to the contrary, an exception is made that permits the consideration of such evidence where there is proof of a recognized usage that has grown into a custom, to graduate professional charges with reference to the financial condition of the patient, so that it may be considered that services were rendered by the physician and accepted by the patient in contemplation of it. The general custom must be considered in determining the intent of the parties and is in effect a part of the contract between them unless the contract manifests a contrary intention.

PHYSICIAN'S OFFER TO REMEDY RESULT OF MALPRACTICE IS NOT A DEFENSE

Thackery *vs.* Helfrich (Ohio), 175 N.E.R. 449

The refusal of a patient to allow his physician to perform an operation to remedy damage caused by the physician's allegedly negligent treatment is no defense in an action against the physician for malpractice.

EDITORIAL

LEON J. MENVILLE, M.D. . . . *Editor*
BUNDY ALLEN, M.D. . . *Associate Editor*

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INTRATHORACIC MANIFESTATIONS OF LYMPHOBLASTOMA

Although Malpighi,[1] in the latter half of the seventeenth century, and Morgagni, in 1769, noted a disease or group of diseases which attacked the lymphatic system primarily, Hodgkin[2] is usually regarded as their collator and attestor. In 1832 he described "some morbid appearances of the absorbent glands and spleen," and recorded seven cases. His junior, Wilks,[3] collected 15 cases, and perpetuated Hodgkin's memory by naming the syndrome for him. No attempt was made to distinguish the various members of the group. Virchow, who was the first to make an effort at intelligent classification of the various types originally designated as "Hodgkin's disease," separated lymphosarcoma and the leukemias from the group. The difficulty of accurate classification, even when tissue is available for microscopic examination, has led to the use of the generic terms, "lymphoblastoma" or "malignant lymphoma." Classification of the various types of the disease in one group has the sanction of numerous pathologists, including Mallory,[4] who believes that they are different manifestations of one disease, a malignant lymphatic neoplasm.

The nature of lymphoblastoma has long been discussed and, although many theories of its etiology have been propounded, the actual cause is still obscure. The cardinal sign of lymphoblastoma is glandular enlargement. This group of diseases may, however, involve any part of the body. The skin, the gastro-intestinal tract, or the urinary tract, the spleen, liver, kidneys, or lungs may be invaded. The functional integrity of the connective tissues or of the bony framework may be seriously impaired.

The intrathoracic manifestations of lymphoblastoma have been admirably reviewed in the comprehensive work of Kirklin and Hefke.[5] They found roentgenologic manifestations of intrathoracic disease in 50 per cent of cases of Hodgkin's disease, and in 20 per cent of the cases of lymphosarcoma and of leukemia. Wessler and Greene[6] found mediastinal involvement in 100 per cent, Whitaker[7] in 30 per cent (autopsy), and Kruchen[8] in 65 per cent of the cases of Hodgkin's disease.

The character of the intrathoracic changes in lymphoblastoma is quite variable; there is probably no roentgenologic syndrome distinctive of any one type or of the group. Wessler and Greene distinguished four types of involvement in Hodgkin's disease: the mediastinal tumor; infiltrative type; isolated nodules or metastases in the

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[2] THOMAS HODGKIN: On Some Morbid Appearances of the Absorbent Glands and Spleen. Med. Chir. Trans., London, 1832, XVII, 68-114.

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lung, and discrete nodes at the root of the lungs. They considered the latter the most common type of involvement. To them, the right paratracheal node was of the greatest interest, and its enlargement a diagnostic criterion for Hodgkin's disease. After a review of 26 cases of Hodgkin's disease, Lemon and Doyle[9] stated: "In general, Hodgkin's disease is suspected when the roentgenogram reveals a bilateral feathery shadow passing outward from each hilus." Whitaker used the classification of Wessler and Greene in 40 cases, and likewise concluded that discrete nodes could be found in the hilum in the majority of cases. Mediastinal tumor was next in frequency, and actual pulmonary infiltration third. He found no case with isolated nodules in the pulmonary parenchyma.

Kirklin and Hefke divide their cases of Hodgkin's disease into two large groups. Group 1 are those in which only the lymphatic glands are involved; in Group 2 are those with pulmonary infiltration, with or without involvement of the nodes. Of their 40 cases, 62.5 per cent could be classified under Group 1, and 30 per cent under Group 2. Of the latter, glandular involvement was absent in only one case. In 65 per cent of all cases a definite shadow of a paratracheal node was visualized on the right side. Of the cases with pulmonary involvement, well defined nodules of the metastatic type were found in 12.5 per cent; the majority showed infiltration into the lungs, originating from the affected nodes. A similar investigation of 17 cases of lymphosarcoma revealed bilateral lobulated mediastinal widening in 10, a unilateral large oval mass in two, localized discrete nodes in four, and pulmonary infiltration in four. In 10 cases of leukemia four were found with definite pulmonary infiltration. Enlarged nodes were seen in all cases, and discrete nodes in five.

My studies have been limited to 17 cases of lymphoblastoma with intrathoracic changes. Of these, 14 were proved cases of Hodgkin's disease, two of chronic lymphatic leukemia, and one of lymphosarcoma.

In nine of the cases with Hodgkin's disease, there was actual pulmonary infiltration, accompanied in each instance by nodal enlargement in the hilum, mediastinum, or both. The majority of the patients with infiltrative pulmonary lesions had been ill for over a year; it, therefore, seems probable that this type of lesion represents a relatively late stage of the disease. In three instances, a progressive increase in the pulmonary infiltration was demonstrated, in spite of adequate roentgentherapy. The response of this type of lesion to X-ray therapy was usually less satisfactory than that of the cases with pure glandular enlargement. The typical manifestation was a feathery infiltration extending radially from an enlarged hilum. In a majority of cases there was also mediastinal glandular enlargement, but none was visualized in three cases. In only one case was an isolated nodule demonstrated in the pulmonary parenchyma and this did not present the typical appearance of a metastatic nodule. In one case there was complete opacity of the upper two-thirds of the right lung field, suggestive of lobar pneumonia or a primary malignant process. In five cases the intrathoracic changes were limited to glandular enlargements; in two of these, there was extreme bilateral mediastinal widening, as well as hilar enlargement. In one there was less marked widening, and in two the adenopathy was limited to the superior mediastinum.

There was no demonstrable enlargement of the right paratracheal nodes in only four of the group of 14 cases. Right paratra-

[9]W. S. Lemon and J. B. Doyle: Clinical Observations of Hodgkin's Disease with Special Reference to Mediastinal Involvement. Am. Jour. Med. Sci., 1921, CLXII, 516-525.

cheal gland involvement is also frequent in malignant lymphadenopathy, so this cannot be construed as a diagnostic sign of Hodgkin's disease. The left lung root is encircled by the rigid aortic arch and does not permit expansion of enlarged lymph nodes. The right hilum, which is encircled by the less resistant vena azygos major and superior vena cava, offers space for the enlargement of glands. This anatomic peculiarity undoubtedly is a factor in the higher incidence of adenopathy on the right.

In one case of chronic lymphatic leukemia, there was a nodular enlargement in each hilum, with no pulmonary lesion. In the other there was a feathery pulmonary infiltration, but less extensive and more indistinct than that seen in any case of Hodgkin's disease.

In the case of lymphosarcoma, there was an enlargement of the superior mediastinum continuous with a supraclavicular lymphatic tumor.

The relative frequency of involvement of the intrathoracic structures in lymphoblastoma makes it necessary to bear this condition in mind in the diagnostic consideration of any unusual pulmonary, mediastinal, or hilar lesion. Although differential diagnosis of various members of the group may be impossible, it is often possible to recognize the condition as lymphoblastoma. The most important criterion of diagnosis is glandular involvement, and increased prominence of the right paratracheal glands is a common manifestation. In my experience a feathery pulmonary infiltration accompanied by enlargement of the hilar glands is next in frequency. However, the roentgenologic manifestations will necessarily vary according to the stage of the disease.

H. C. Ochsner, M.D.

Methodist Hospital,
Indianapolis

ANNOUNCEMENTS

THE COMING ANNUAL MEETING

ATLANTIC CITY'S ADVANTAGES

Atlantic City as a health and pleasure resort is popular the year round. When the Annual Meeting of the Radiological Society of North America is held there, November 28 to December 2, its theme song will be that satisfactory one, "No Snow on the Boardwalk."

Situated on an island which juts out more than six miles into the ocean, Atlantic City is warmed by the Gulf Stream in winter and is, therefore, popular as a resort during the so-called cold months as well as in summer when fanned by ocean breezes. The famous Boardwalk, sixty feet wide, overlooking the sea, is sheltered from any wintry winds from the landward, and is lined for miles on one side with interesting shops and stores of all kinds; on the other side, piers extending a thousand feet or more into the sea are alive with entertainments and music. Lights flank the famous walk and convert it into a veritable fairyland at night. Night promenading or roller-chairing is most enjoyable during the winter months. There are orchestra concerts, dancing in the hotels and on the piers, indoor swimming pools, numerous theaters, "movies" and varied entertainment. In the daytime, one has the choice of a round of golf in the fresh, invigorating sea air; ice skating in the Auditorium, or perhaps a canter on the beach at the ocean's edge.

Plans are maturing for one of the best gatherings in the history of the Radiological Society—a meeting which should go down in history for the amount of constructive work accomplished.

The sessions are to be held in the beautiful new Haddon Hall, which meets the most exacting demands from the standpoints of comfort, elegance, and service. Especially

attractive rates have been quoted for the accommodation of the members of the Society and their families.

The meeting place this year offers a happy opportunity of enjoying a combination vacation and educational trip at one of the Nation's most famous playgrounds.

Haddon Hall Hotel, Atlantic City, where the Eighteenth Annual Meeting of the Radiological Society of North America is to be held Nov. 28–Dec. 2, 1932.

Atlantic City holds a leading place as a meeting city by reason of its natural advantages, consisting, primarily, of delightful climate and accessibility to a territory in which millions of persons reside. It is almost in the same relation to Philadelphia and New York City as are the suburbs of these cities, and it is little farther from Baltimore and Washington. Pittsburgh, Boston, Cleveland, and Buffalo are but short trips away. It is next-door-neighbor to dozens of smaller cities—a comparatively short journey from hundreds of towns within a 500-mile radius. Railways, highways, and now airways connect Atlantic City with everywhere.

When it is possible to get to and from a place quickly and inexpensively, to enjoy while there an unmatched climate, to find opportunities for pleasure many and varied, to be in the delightful surroundings of a modern hotel, it is small wonder that people come to Atlantic City, and come back again.

LOCAL COMMITTEES OF ARRANGEMENTS

Chairman: W. C. Wescott, M.D., Atlantic City, N. J.

Vice-chairman: Charles B. Kaighn, M.D. (by invitation), Atlantic City, N. J.

William G. Herrman, M.D., Asbury Park, N. J.

Robert A. Bradley, M.D. (by invitation), Atlantic City, N. J.

Harold S. Davidson, M.D., President County Medical Society (by invitation), Atlantic City, N. J.

Walt P. Conaway, M.D., Ex-president New Jersey State Medical Society (by invitation), Atlantic City, N. J.

John S. Irvin, M.D., in charge of publicity for the Atlantic County Medical Society (by invitation), Atlantic City, N. J.

LADIES' ENTERTAINMENT COMMITTEE

Chairwoman: Mrs. W. C. Wescott
Vice-chairwoman: Mrs. Charles B. Kaighn
Members of the Committee to be appointed later.

BANQUET NIGHT COMMITTEE

W. C. Wescott, M.D.
Charles B. Kaighn, M.D.
Robert A. Bradley, M.D.

COMMUNICATION

CO-OPERATION FROM CONTRIBUTORS

The Editor wishes to make grateful acknowledgment to a certain member of the Society who had lightened the task of asking contributors of papers to bear the expense of their illustrations. In reply to one such letter came the following reply:

"There is no help for it but for every one to do the best he can until the sun shines again. You may proceed with the publication of my paper and bill me for the actual cost of the illustrations.

"The clinic with which I am associated does not bear any of the cost of preparation of papers or purchase and mailing of reprints, hence any such cost falls on the individual who has papers published. This has cost me personally quite a bit of money in the last three or four years, but I feel that the stimulus to study and the increased range of articles read has more than compensated me for the money expended. When one works in a small clinic he must either keep up with the work of others or stagnate, and I find that preparing an article for publication necessitates careful study of the literature. . . . It has been difficult to keep our laboratory open, and profit is practically *nil*."

BOOK REVIEW

CLINICAL ROENTGEN PATHOLOGY OF THORACIC LESIONS. By WILLIAM H. MEYER, M.D., Professor of Roentgenology in the New York Post-graduate Medical School of Columbia University, and Director of Roentgenology in the New York Post-graduate Hospital. Cloth; 272 pages, with 183 illustrations. Published by Lea and Febiger, Philadelphia, 1932. Price, $6.00.

In a concise and well organized preface, the author sets forth his reasons for recording the material which his book embodies. It is a textbook which shall serve as a record and guide for previous and future students and associates of the Department of Roentgenology of the New York Post-graduate Medical School. Dr. Meyer explains the subsequent contents of each of the book's six sections.

By way of introduction, he discusses the fundamentals of roentgen interpretation. Under this heading, he considers the variations within normal limits, structural density, pathology, postural variations, motion, and the physics of light transmission and ray divergence. Section I is a roentgen study of the thorax, and it is an excellent basic consideration of technic, anatomy, and the locale of possible lesions. Each of the remaining sections is admirably described by its title: II, Roentgen Pathology; III, Diseases Affecting the Thoracic Cage; IV, Special Diseases of the Respiratory System; V, Lesions of the Heart and Pericardium; VI, The Esophagus and Subphrenic Organs in Relation to Intrathoracic Pathology.

The outstanding characteristics of the book are that it is brief, simple, and accurate. The pen-and-ink sketches are very interesting and instructive. It is evident that the book is the work of a man who has had extensive experience in teaching, and consequently, it is especially valuable for the student and beginner. Excellent editing and a complete index augment its availability as a ready reference.

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PAGET'S DISEASE

Radiographic Examination of a Paget's Skull. L. Rocher and Ch. Lasserre. Arch. de l'Électricité méd., July, 1931, XXXIX, 241-244.

The authors examined roentgenograms of a skull, affected with Paget's disease, from the anatomic collection of the School of Medicine of Turin.

It was observed that in the lateral view the vertical diameter was decreased and the anteroposterior diameter was increased when compared to a normal skull. The total capacity of the affected skull remained unchanged, however, for the loss in the vertical dimension was compensated for by gain in the anteroposterior. The vault appeared very much thickened and condensed, varying from 2 to 3 centimeters. The internal table was distinct in the frontal and occipital regions, and the contour of the external table was equally clear throughout. Several lacunæ were evident in the region of the external table in the parietal and occipital areas, and a small island of bone surrounded by a rarefied zone was observed in the frontal region. Thus, areas of increased and decreased density were found side by side.

The lesions of the base were considered characteristic. The entire base, with the exception of the occipital foramen, appeared to be depressed and flattened, and the cerebellar fossa was reduced in size. The anterior cerebral fossa and the sella turcica, however, appeared unchanged. No changes were found in the frontal sinuses or in the bones of the face.

The anteroposterior view revealed very conspicuous changes and some asymmetry in the parietal regions. A small island of condensed bone, surrounded by a spongy area with a sharp line of demarcation, was noted on the left. A roentgenogram made in the position of Hirtz showed the occipital foramen narrowed, with marked thickening of bone along its margin.

J. N. Ané, M.D.

A Contribution to Osteodystrophia Generalisata (von Recklinghausen). F. Schmidt. Röntgenpraxis, Jan. 15, 1932, IV, 59-67.

Osteitis deformans (Paget's), osteitis fibrosa generalisata (von Recklinghausen), osteitis localisata, and leontiasis ossea are considered by most authors to be of the same origin and are often called osteitis fibrosa. Recently, some authors want to separate Paget's from Recklinghausen's disease as an entirely distinct entity. The latter is supposed to be a hyperparathyroidism (hypercalcemia, hyperphosphaturia and increase in calcium excretion in the urine).

A case of osteitis fibrosa generalisata in a 12-year-old boy is described in detail, and several illustrations show the bone changes which were present in a characteristic picture of cystic destruction in many bones. There was an excessive excretion of calcium in the urine, but no other evidence of hyperparathyroidism. Surgery or autopsy reports were not available for further information.

H. W. Hefke, M.D.

RADIATION INJURIES

Quality of Rays, Roentgen Illness, and the Red Blood Picture. Dietel. Schweiz. med. Wchnschr., April 16, 1932, LXII, 386, 387.

Clinical observations led to the question of whether, in addition to the intensity and region of irradiation, the quality of radiation might play a part in the development of roentgen sickness. The author experimented with: (1) Radium filtered through 1 mm. brass; (2) X-rays 180 K.V., 2.5 mm. Cu; (3) X-rays 170 K.V., 1 mm. Cu; (4) X-rays 125 K.V., 0.3 mm. Cu. The distance was kept constant at 50 centimeters. The soft irradiation (4) produced the most severe reaction, even when the intensity (r per minute) was the same as in (3). The first and second types of irradiation were borne best.

Studies of the blood carried out for five hours after irradiation revealed a diminution in erythrocytes proportional in many cases to the amount of roentgen intoxication. There was only a slight diminution of hemoglobin, and consequently an increase in the color index. Injection into guinea pigs of serum of patients who had roentgen illness produced a marked diminution in erythrocytes. The author feels that this reaction is due to a toxic material in the blood or in irradiated tissues. He found no evidence that it might be due to ozone or nitrous compounds in the air. On the whole, hard rays of not too great intensity are best tolerated.

H. C. Ochsner, M.D.

A Roentgen Carcinoma Healed by Radium. A. H. Roffo. Strahlentherapie, April 13, 1932, XLIII, 757-766.

The author discusses in general the use of radium in the treatment of roentgen carcinoma and appends the report of a radiologist, written by the latter, who had been suffering for about 20 years from chronic radiodermatitis of both hands, with definite malignant degeneration. In October, 1930, all lesions were treated by radium (exact dosage given in the paper). They healed within 2 months' time and have remained well for a year. Photographs of the hands before and after treatment are appended.

Ernst A. Pohle, M.D., Ph.D.

RESPIRATORY TRACT

A Graphic Method of Recording the Respiratory Excursion of the Diaphragm. Harold Thomas. Am. Jour. Roentgenol. and Rad. Ther., December, 1931, XXVI, 878-880.

A relatively simple technic has been devised for

obtaining on a single film of the chest the diaphragmatic excursions and the change in position of the mediastinal contents and ribs. Such a radiographic study should be particularly helpful in any case which cannot be moved to the fluoroscopic room, in which some lesion in the vicinity of the diaphragm is suspected. In order to obtain good contrasting density of the diaphragm outlines at the two levels, three-fourths to seven-eighths of the chest exposure should be made, with the breath held at expiration, and only one-fourth to one-eighth of the exposure made at held inspiration.

J. E. HABBE, M.D.

Acute Silicosis. Earle M. Chapman. Jour. Am. Med. Assn., April 23, 1932, XCVIII, 1439-1441.

This is a report of three cases of acute silicosis following comparatively short exposure to alkaline silica mixtures in the manufacture of scouring soaps. The appearance of respiratory symptoms after eight, twenty-one, and twenty-nine months of exposure to an alkaline dust of high silica content marks a more rapid and severe silicosis than is usual. MacDonald reported rapidly fatal cases in two young girls employed for two and one-fourth years packing a similar type of soap. Acute silicosis is a real industrial hazard, hitherto unrecorded in the medical literature in this country.

C. G. SUTHERLAND, M.D.

Some Considerations of the "Standardized" Technic in the Radiologic Examination of the Respiratory Tract. F. Bruno Omizzolo. Archivio di Radiologia, January-February, 1932, VIII, 81-91.

The author points out the fact that in radiography of the chest there are many "standard" technics, some using low voltage and some high voltage at widely varying target skin distances with and without diaphragms. A good radiograph should have the following qualities: definition, richness of detail, contrast, and conservation of dimensions. He shows that there is no universal standard but that each radiologist uses his own technic and that it would be desirable to have some fixed conditions established and accepted.

E. T. LEDDY, M.D.

THE SKIN (THERAPY)

The Radiation Treatment of Some Skin Affections. C. M. Henry. Canadian Med. Assn. Jour., December, 1931, XXV, 702-704.

Many skin affections which do not respond to ordinary therapy will clear up under radiation therapy. It is just as important to make a correct diagnosis in skin affections before beginning radiation treatment, as it is if any other type of treatment is being used. Skin affections, due to focal infections of the teeth, adenoids, sinuses, gastro-intestinal, tubal, or prostatic conditions, also those due to addiction or susceptibility to drugs or toxins from without, or to deficiency or overaction of secretory glands within the body, must be eliminated. Diabetic and nervous disturbances also require careful scrutiny.

Acne, in its various forms, is one of the most common infections. When it does not respond to medical, dietetic, or serum treatment, it will often respond to radiation therapy. Whether the infection is local or general, good results are obtained by a combination of ultra-violet and X-ray treatment. The patient is given one-sixth of an erythema dose of X-rays every five to seven days, for four or five exposures; then exposure to the mercury quartz lamp at a 20-inch skin distance, 70 ma., to effect a skin erythema, every second or third day, and continued for a period of two or three weeks.

Impetigo, when treated at the beginning of an infection, will usually be cured by one-fourth of an X-ray erythema dose, but if the infection has been present for several days, quicker results are obtained by the combination of X-rays and quartz lamp. One exposure of X-rays, followed by the lamp at two-day intervals, will clear up the condition.

Eczema is the result of a skin idiosyncrasy to precipitating causes. It often responds to radiation therapy when all other measures fail. Either X-ray or quartz lamp or a combination of both may be used. Careful judgment must be exercised in treating the acute forms by radiotherapy.

Psoriasis will often respond to the quartz lamp applied very closely or in contact, the water-cooled lamp being used. If the disease is widespread over the body, the combination of X-rays and quartz lamp will produce good results, but a tendency to relapse is very frequent. Treating the ovary, pituitary, thyroid, and suprarenal glands with the X-ray will often result in a cure when general radiation fails.

Furunculosis and carbuncles may be aborted if the treatment by X-rays is given in the inflammatory stages, but if pus is present it is advisable to incise and then treat with the X-ray.

Warts, corns, and moles disappear when rather heavy unfiltered doses of X-rays are given. The surrounding skin area must be protected by lead. X-rays are a specific cure for plantar warts.

Erysipelas is not relieved so specifically and effectively by any other measure as by the X-ray. One exposure will give results as surprising and immediate as when antitoxin is administered for diphtheria. The earlier the treatment is given the quicker the results.

Actinomycosis and blastomycosis may be benefited and often cured by repeated treatments of X-rays of moderate dosage. The assistance of full doses of potassium iodide is also valuable in ray-fungus conditions.

Nevi are better treated by a radium plaque or

pack, as it is difficult to keep a child quiet for X-ray treatment. When radium is used, it is necessary to repeat the treatment at two or three monthly intervals until the desired result is obtained. X-ray therapy may often be employed in one dose. For some nevi surgical diathermy is advisable. Port-wine marks are not usually amenable to any form of therapy.

Keloid is favorably influenced by either radium or the X-ray. The dense fibrous types require treatment every two or three months over an extended period of time.

Alopecia areata yields, in many cases, to the ultraviolet rays. The technic is to use the water-cooled lamp, applied at a distance of one-half inch from the area, administering a full erythema dose twice, at three-day intervals. This is repeated for three or four series at two weekly intervals.

Adenoma will receive benefit from X-ray exposures of moderate intensity, whether it be due to tuberculosis, Hodgkin's disease, lymphosarcoma, or some form of blastomycosis, or to thyroid intoxication. Treatments should be applied at intervals of a few weeks.

Rodent ulcers, senile keratosis, squamous epithelioma, and endothelioma of the skin yield readily to X-ray and radium therapy, and the results are likely to be more lasting than if surgery is employed, while there is no resulting deformity and no mortality. The percentage of clinical cures is higher than by any other known method of treatment.

L. J. Carter, M.D.

Indications for Roentgentherapy in Skin Diseases. Stefan R. Brünauer. Strahlentherapie, April 13, 1932, XLIII, 601-630.

This excellent article unfortunately does not lend itself to abstracting, but is well worth reading in the original or in translation. It offers a most complete analysis of the principles underlying the application of roentgen rays in the treatment of skin diseases. There is hardly a dermatologic condition omitted, and the paper is heartily recommended for study in the original.

Ernst A. Pohle, M.D., Ph.D.

A New Indirect Method for Roentgenotherapy of Dyshydrosis and Eczema. D. v. Kéméri. Strahlentherapie, March 9, 1932, XLIII, 597-600.

The author believes that in most cases of dyshydrosis and certain types of eczema there exists a focal infection with an organism. Tonsils, periapical abscess, pyorrhea, sinusitis, otitis, prostatic abscess, appendicitis, or cystitis may represent the focus of infection. He observed many cases in which dyshydrosis and eczema promptly disappeared after these foci had been cleared up. Latent processes in the hila or in the lungs were also seen in this group. In several cases the author succeeded in activating the pathologic process. The hila were treated with 30 per cent H.E.D. (120 K.V., 0.5 mm. Zn). The anterior field was given first; the posterior field one week later. In suspected sinusitis and prostatitis 60 per cent H.E.D. were given through 1 mm. Al. The method is recommended to radiologists for trial and study.

Ernst A. Pohle, M.D., Ph.D.

Morphology and Roentgenographic Technic of the "Fissura Orbitalis Inferior" and of the Adjacent Parts. Giuseppe Bartel. La Radiologia Medica, December, 1931, XVIII, 1541-1570.

Exact interpretation of the details of a roentgenographic image of the cranium demands profound familiarity with the corresponding anatomic substratum. In addition, account must be taken of the laws of projection and absorption.

On the basis of diagrams of various projections, the author illustrates certain fundamental ideas as regards roentgenologic examination of the cranium in general, and discusses at length the projection with oblique rays, as used in studying the cranium. This method, it is claimed, renders accessible to roentgenologic investigation the lateral and posterior portions of the orbit, not otherwise subject to delineation. This is followed by an exact anatomic description of the *fissura orbitalis inferior* based on personal study through appropriate roentgenographic projection, which promises to be of distinct diagnostic value in studying the pathology of the region in question.

W. W. Whitelock, Ph.D.

THE SPINE (DIAGNOSIS)

Teleroentgenograms of the Vertebral Spine. W. Jaeger. Röntgenpraxis, March 1, 1932, IV, 193-209.

Teleroentgenograms of the heart and lungs were introduced in 1903 by Köhler and are used in almost all institutes. Baer introduced the same technic (1.5-meter distance) for the vertebral spine. The author has used it since 1929, and gives a critical review of the whole question. A 10-kilowatt roentgen tube is necessary for such work. The broad focus is compensated for by the great distance. The skin exposure (with 0.5 mm. of aluminum as filter) compares favorably with the old technic. Fixation of the patient is very important, as the exposure time is necessarily rather long. The author uses special apparatus for it. The details must be read in the original article. The quality of such roentgenograms is worth the extra time and effort; details are fine and there is no distortion. Unquestionably, there is still room for further improvement in this field.

H. W. Hefke, M.D.